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IMPROVED TELE-PHOTOGRAPHY.*

By Dr. Alfred Gradenwitz.

The possibility of taking photographs at distances where ordinary objectives cease to be of use, obviously appeals to scientists, travelers, artists, architects, and to members of the military profession. Though this problem has been studied for some years by many investigators, really satisfactory tele-photographic lenses have been obtained only in recent years.

In the course of a visit to the Goerz optical works of Friedenau, near Berlin, the writer had an opportunity of acquainting himself with the methods used and results obtained by that company which was the first to design really available tele-objectives. He is indebted to the courtesy of the firm for reproducing some specimen tele-photographs.

As the human eye, in order to see better from a distance, uses telescopes, any ordinary photographic objective can be made to produce enlarged views of an object by the addition of a magnifying lens. This lens, called "tele-negative," need not be connected permanently with the ordinary objective (which is called "tele-positive"), a loose connection by means of a removable short tube being quite sufficient. Then the objective can be used at will both in connection with ordinary views and with tele-photographs. An important feature is that tele-objectives can be used to advantage in many cases where ordinary objectives of corresponding focus could as well be used. Tele-objectives are preferable in such cases, because they are lighter, cheaper, and more handy than ordinary objectives of such great focal dimensions, while the sharpness and definition of the images are about the same in both cases. The angle of vision, it is true, is smaller, and the luminous intensity usually less, so that instantaneous views can be obtained only with medium magnifications. Our illustrations, by the way, represent some rather satisfactory instances of such instantaneous views.

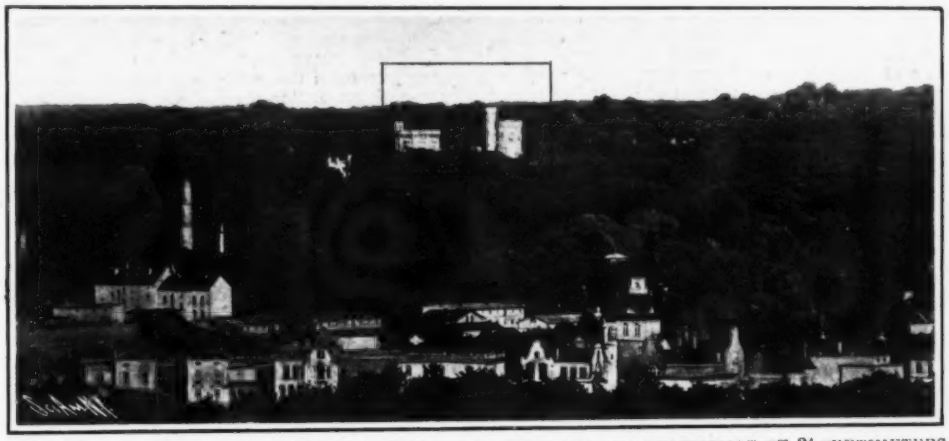
It should be remembered that only the central part of the image produced by the ordinary objective is enlarged to a tele-photographic image, so that only the central definition of the tele-positive need be satisfactory. The focus and luminous intensity of the ordinary photographic objective obviously influence in the first place the efficiency of the whole outfit. The focus of the tele-negative or additional lens is generally two or three times shorter than that of the corresponding tele-positive, this difference being increased whenever any especially high magnifying power is desired. It should be remembered that the ratio of aperture of the additional lens does not exert any influence on the luminous power of the tele-photographic outfit. The magnifying power is given by the distance between the tele-negative and tele-positive. If this distance be equal to the focus of the latter, the tele-photographic apparatus will produce images of given objects in the same dimensions as the tele-positive or ordinary objective alone. As the tele-negative is placed nearer to the positive, the magnifying power will be increased, becoming infinite as the distance between the two becomes equivalent to the difference of the two lengths of focus. A magnifying power of between 3 and 20 diameters can thus be readily obtained by means of a range of displacement smaller than the focus of the tele-negative.

The "equivalent focus" of the tele-objective is dependent on the focus of the positive and the magnification used. If, for instance, the positive be 20 centimeters in focus and if the tele-objective have a magnifying power of 5, the equivalent focus of the tele-objective will be $20 \times 5 = 100$ centimeters.

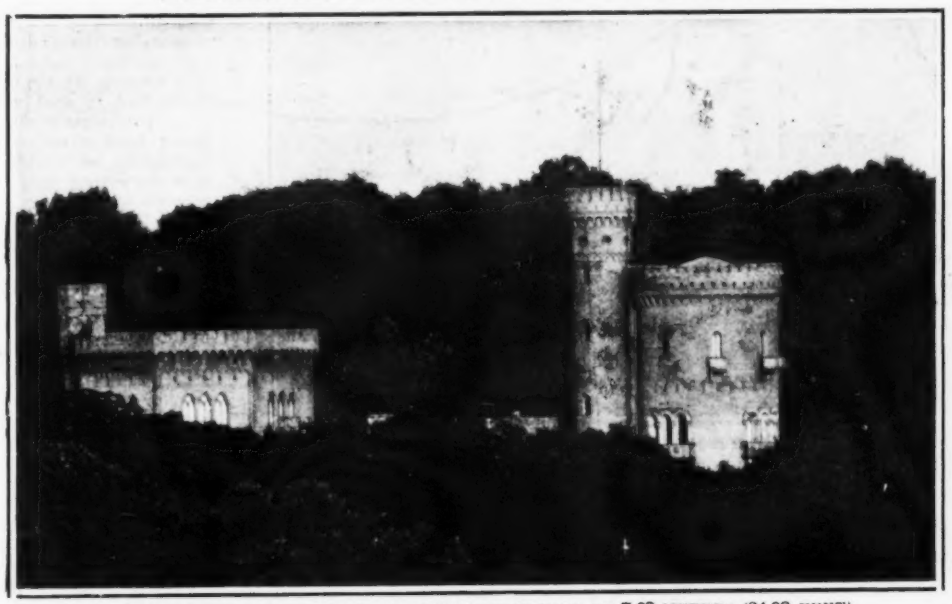
The relative aperture of the tele-objective decreases in the same ratio as the focus increases along with the magnifying power. In the instance just mentioned a tele-objective, whose positive has an aperture of F : 4 will only have an aperture of F : $4 \times 5 =$ F : 20. The time of exposure will naturally have to be correspondingly longer than in the case where an ordinary objective is used. Instantaneous views can accordingly be obtained only in the case of objectives of great luminous power and relatively small magnification.

In many cases it is impossible with an ordinary photographic outfit to obtain sufficiently distinct views of remote objects, to which the photographer cannot approach for some reason or other, while a subsequent enlargement is not as successful as an original view on a larger scale. In such cases the use of tele-objectives proves very efficient. Another instance from the province of landscape photography is the taking of views of inaccessible mountains when, owing to the magnitude of the objects, rather important distances are to be dealt with. The exceptionally favorable luminous conditions and the

*Specially prepared for the Scientific American Supplement.



BABELSBERG CASTLE, NEAR POTSDAM. VIEW TAKEN WITH DOUBLE ANASTIGMAT OF 24 CENTIMETERS (9.4 INCHES) FOCUS FROM A DISTANCE OF 2,600 METERS (8,528 FEET).



BABELSBERG CASTLE TAKEN WITH TELE-OBJECTIVE OF 7.68 METERS (24.98 FEET).

HALL OF CARYATIDES IN ERECHTHEION, ACROPOLIS, ATHENS. VIEW TAKEN WITH TELE-PHOTO LENS FROM A DISTANCE OF 70 METERS (229.6 FEET).

SOME REMARKABLE TELE-PHOTOGRAPHIC PICTURES.

very great distances usually obtaining on the sea make the use of tele-objectives for instantaneous views especially advantageous, as illustrated.

One of the easiest and most pleasing kinds of tele-photographic work is the taking of architectural photographs, where sharply outlined and immovable objects are mostly concerned. For the same reason the use of especially high magnifications is easily possible. The first two views on our front page were taken from a distance of nearly a mile and three-quarters.

In architectural photography, views of entire buildings are not always required, but rather only certain details, which cannot be reproduced by means of ordinary objectives unless some expensive outfit is resorted to. Such details can, however, be readily photographed from great distances with a tele-objective, and a very striking example is the Hall of Caryatides in the Athens Erechtheion (Acropolis) which by means of an ordinary objective of small focus could be photographed on a larger scale only when close to the object. Such a view, moreover, could only be taken with the camera pointing obliquely upward or else with the aid of a special scaffold. But with the tele-objective available, a view can be readily taken from a distance of some three hundred feet with the camera placed horizontally, as can be seen from the sample photograph below. The tele-apparatus in the case of the above figures was placed somewhat more to the left than the ordinary apparatus, so as to better disengage the various figures.

Portrait photographers will also profit greatly by tele-objectives both when working in the open and in the studio. In the case of large photographs of heads, an objective of very long focus with correspondingly great length of bellows should be used, or else the person should be approached very closely, if the objective has a short focus. Now, in the latter case, the well-known deformations of the object will be noted. Long-focus objectives are, as a rule, at the disposal only of professional photographers, while those of amateurs have mostly short or medium foci. Whenever such an objective is transformed into a tele-objective by the addition of a magnifying lens, it will be

THE ERECHTHEION, ACROPOLIS, ATHENS. PHOTOGRAPHED WITH AN ORDINARY DOUBLE ANASTIGMAT FROM A DISTANCE OF 70 METERS (229.6 FEET).

AN EXCELLENT SAMPLE PICTURE SHOWING POSSIBILITIES OF TELE-PHOTOGRAPHY.

quite available in photographing large heads with a correspondingly small length of bellows.

What has been said above in regard to all these various divergent branches of photographing, obviously applies as well to the uses of explorers. For numerous reasons it is desirable, and even necessary, to equip every scientific expedition with tele-objectives. The reproduction of animal life in the deserts extremely seldom proves successful in the case of ordinary photographic apparatus, owing to the impossibility of approaching the animals to within the necessary distance, whereas this task is readily solved by the aid of tele-objectives of especially high luminous power.

In the extensive field of military photography, the use of tele-objectives will assume an important part in connection with the intelligence service when objective documents will be obtained in the place of subjective observation. The apparatus can be used on hand or movable cameras for balloon photographs, coast views from shipboard, or the ordinary use on land, or fixed or stationary cameras for fortifications and the like.

HYDROCARBON OILS AND THEIR VALUE AS LUBRICANTS, WITH A FEW PRACTICAL TESTS.*

WHAT we have to deal with is not the friction of opinions, but those of metals. When you take two metals and rub them together, you will find more or less wear which comes from the irregularities and asperities that are on the surface. Now, what engineers would have to deal with is the wear and tear or the friction which helps to tear these irregularities off. You know that the finest machinery that we can manufacture to-day, our locomotives, street cars, and everything would finally stop, if it were not for our lubricating oils, to make a film that saves the metals.

To prevent this friction is the desideratum of the engineer, thereby saving wear and tear and loss of power. Theoretically, if friction is the result of two surfaces rubbing together, to reduce this we must take steps to keep the two surfaces apart. If we can introduce between the moving surfaces, say, some substance, like oil, with adhesive properties (that is, by adhesion we mean that which clings or adheres to the metal), we should then have two films created between the surfaces which adhere to the two metals, and when the metals rub over each other, instead of abrading, the friction takes place on the two films.

It will be evident to you at once that the thickness of these films has a great deal to do with the saving of abrasion. We must not only have adhesive properties, but cohesive as well, and by cohesion we mean the power of the particles to hold themselves together and resist disruption.

The name we give to these combined properties of an oil is viscosity. Now, if it were not for viscosity, a very thin film would allow these metals to come together.

The surfaces of journals and bearings, rings and cylinder walls are not, of course, perfectly smooth, and that is why we must fill up these little spaces if we would have perfect lubrication. Under heavy loads and slow speeds there is a tendency to force the particles of the lubricant asunder, thereby permitting the films to become too thin, and consequently cause the metal surfaces to rub, abrade and wear.

Take water, kerosene, alcohol; these are strongly adhesive. Mercury is strongly cohesive, but mercury would never do for a lubricant, because it has no adhesive properties; therefore, in dealing with oils, we must select not only those oils with adhesive properties, but those with cohesive properties. Suppose we take a liquid that is semi-solid. Now, it is undoubtedly true that the lubricant will keep the materials apart, but what will happen? We have such a thing as fluid friction, that is, the friction of the moving molecules, and if we use a lubricant which is too strongly cohesive, the result will be, we increase the friction of the oil; and the rule in mechanics is to use an oil that is as fluid as will sustain the load.

The fluidity of oil has a great deal to do with the carrying away of heat, and that is a very important thing, and the higher the viscosity of an oil, the slower it is carried away.

In the engine room we have to deal with very many different conditions, and that is why there is really no set rule by which you can prescribe an oil. We have to deal with heavy loads, slow speeds, light loads and fast-running machinery, bath lubrication, pad lubrication, all ordinary applications of lubricant, hot engine rooms, cold engine rooms, all of which have to be classified under the head of lubrication under ordinary atmospheric conditions. It is on account of these varied conditions that the selection of an oil is largely a matter of judgment.

In the purchasing of oils it is usually done under some brand, but the engineer is really ignorant of what the specifications are of the oils which he purchases. We have seen before that the properties of an oil—viscosity, for example—are valuable, and that different viscosities should be used under different conditions, but does the engineer know what the specifications are of these oils that he uses? Certainly he has no standard to go by, and I, for one, believe that all oils should be sold under specifications, and the engineer should be given these specifications as an index and a guide for future purchasing. All of the refiners that sell oils to-day sell under specifications and never under brands. I refer only to refiners, not jobbers. Personally, I would not think of buying oils under brands, for I could not select the proper oil for the varied purposes required.

In entering the manufacturing establishment, as I said in the early part of the evening, the conditions under which lubricants are used are so varied that it becomes an intelligent proposition for a salesman to pick out the proper oils for the work, and certain it is that results should be registered in some way, and what better than by the engineer calling for the specification of the oils that are recommended?

There is no question but what the properties of an oil are an index to its value, and we can easily get them with laboratory appliances.

Besides atmospheric conditions we also have to deal with cylinder lubrication. Take the gas engine, for example—and there are very many now used throughout the country; conditions are entirely different. We have temperatures ranging as high as two thousand degrees at the explosive point. True, every attempt is made to cool the cylinder wall by water circulation and air; still, withal, an oil is more or less exposed to the high temperature. It must become obvious to you that the viscosity of an oil at the boiling point, the flash and the fire test, the cold test, and the gravity are all important factors in gas engine lubrication. There is really no oil that will stand the high temperatures, and there is more or less carbonizing. We, therefore, have to consider the quality of the crude oil for non-carbonizing properties.

Twenty years ago the engineer had to deal almost exclusively with animal and vegetable oils—fixed oils they are called. They consisted of sperm, olive, rape, castor, tallow, palm, lard, and neat's foot oils. They were the principal oils used for lubrication. Their properties are a rather high cold test. Their viscosity is really more permanent and stable than our hydrocarbon oils. They are composed of oxygen, hydrogen, and carbon. The fact that they contain oxygen makes them susceptible to atmospheric influences. When these animal and vegetable oils come in contact with the air, they oxidize. Fatty acids are formed which we call free fatty acids, and they will attack metals and will also gum machinery. In cylinder lubrication under extreme heat and moisture this process takes place very rapidly. Twenty years ago we did not carry to exceed fifty or sixty pounds pressure of steam, but even at that the moisture and heat would attack these animal oils, set free the glycerine, and leave the fatty acids behind, which would ball up in the cylinder and attack the cylinder walls and corrode the same. You can, therefore, see that animal oils are not ideal oils for practical purposes. Animal oils are liable to create considerable internal heat under the action of the air, and have caused a great many fires by combustion.

Now, take our hydrocarbon oils. The first that was known of hydrocarbon oils was in Scotland. They found that the shale of Scotland contained more or less oil, and by carrying on destructive distillation, condensing the distillates, oil was produced which, when properly refined, made a suitable lubricant. In this country we soon followed suit, and the first refiners had to deal with shale. Soon, however, the crude petroleum in its natural state was discovered—found floating on the rivers—and was used by the Indians for medicinal purposes, called Seneca oil. The first oils refined were improperly done, and their odor was so offensive that when they were sent to New York city they were called a public nuisance.

Let us enter into the matter of refining oils as we find the process carried on to-day. The first oils refined were from Pennsylvania, and are considered to be the best possible grade. They averaged about 43 Baumé gravity, and are comparatively free from sulphur and asphaltum.

I would dwell for a minute on the different qualities of crude oil. Oils from Ohio contain more or less sulphur and asphaltum. Indiana oils do not stand as high as Ohio; Texas oils are comparatively free from sulphur, but have an asphaltum base; they have a magnificent cold test and are particularly desirable for refrigerating work. It is well that the purchaser of an oil familiarize himself with the stock from which the oil is refined. An expert can tell what crude oil was used and from what State. Crude petroleum has a color or cast that we call the fluorescence, or the bloom. Sometimes oils are debloomed, however, but as a rule you can tell by the color or cast of the oil. Pennsylvania oils—as a rule cylinder goods—have a greenish cast; Texas oils, a dark purple bloom.

It is quite important that the properties of the crude oil be known, because their freedom from sulphur and asphaltum, where heat is applied to the oils, is particularly desirable.

Let us follow through the methods of refining a cylinder oil.

Take the Pennsylvania oil, for example. We have what we call stills—two different kinds. Heat is applied by fire under these stills, whereby we elevate the temperature of the crude oil. Before the oils are introduced to the stills they are settled, strained. In the bottom of these stills are steam pipes. If the refiner is up-to-date he will use superheated steam to facilitate the elevation of the distillates to the condenser. In cylinder oil distillation the work is done rapidly to prevent (in the nomenclature of the refiner) "cracking." Where distillation is carried on slowly the vapors rise lazily and are liable to be condensed before they reach the condenser by the upper part of the still. They fall back again, and really destructive distillation takes place, which works an injury to the lubricating oil.

You no doubt remember one of our New York concerns using the vacuum system of refining oils. This was done to keep the temperature of the oil down as low as possible, and to assist the vapors in passing over to the condenser.

The object of the refiner is to carry off from the crude oil all of the light distillates and leave the residuum in the still free from volatile properties. The flash and fire test of the residuum is gained right in the still.

In refining the crude petroleum I will give you the different products that result. First, we have cymogene, which has a specific gravity of 108 Baumé and is a gas under atmospheric pressure; then we have rhigolene, which is also a gas at 94 Baumé gravity; the

* By Frank Harris Floyd in The International Steam Engineer.

next that comes off is gasoline, which ranges from 84 to 68 gravity; then we have the naphthas, which are used by paint makers; after this comes the kerosene from 46 to 48 Baumé, and following this comes the miners' oils with high fire test for safety. The idea of the refiner is to eliminate from the cylinder oils all of the lighter distillates, which are condensed and are passed to what we call the tail house. Some of the heavier distillates are what we call paraffine stock, and this is sent over to the refrigerating house. This stock with the paraffine in it is cooled very slowly, forms large crystals, and the stock is then put into presses and the oil is squeezed out, leaving behind the paraffine scale, which is afterward refined. This paraffine oil comes under the head of neutral oil and runs at about 30 Baumé gravity. It is used for lubricating light-running machinery. This is sometimes re-run and the residuum is again treated, when this oil will show a higher viscosity and a lower gravity.

The cylinder oil, or the residuum left in the still, is immediately drawn off and sent to the treating house. There is more or less nitrogenous matter in the original crude oil, which must be eliminated. This is done by using a solution of sulphuric acid first, after which a solution of caustic soda is used, and both acids and alkali are washed out, leaving the oils free from nitrogenous matter. The oils are then filtered, sometimes several times, and they are then known as cylinder stocks.

The value of animal oils lies largely in their oily properties and their power to mix with moisture. They are more oily than the hydrocarbon oils. We find the best results are gained in cylinder lubrication by compounding a certain percentage of the animal oils with the hydrocarbon oils of different fire tests.

In filtering oils we lighten in color the oils, which sometimes bring fancy prices. Once filtered, cylinder oil is usually as powerful a lubricant as one desires. For automobile work, however, I must say that I think the repeated filtering removes some of the carbonizing properties of an oil without materially injuring the lubricating value.

Paraffine oils are somewhat different from the neutral oils. We take stocks not altogether suitable for cylinder goods, and they are run to coke in what we call the tar stills. The paraffine distillates are sent over to the crystallizing house and the treatment is somewhat the same as with neutral oils.

We get our heavy engine oils from the paraffine oils, oils of high viscosity.

We have an apparatus for testing the flash and fire test of an oil. Also the standard Tagliabue viscosimeter, which is used by all the independent refiners throughout the country. Also the hydrometer for getting the gravity of an oil.

The flash point is the lowest temperature at which the vapors ignite and the flame goes out. The fire test is the lowest temperature at which the flame becomes permanent. Taking the viscosity of an oil, the universal practice is to use the capillary tube. The more viscous the oil, the slower it will pass through the tube. Cylinder oils are taken at 212 deg.; engine oils at 70 deg.

We also have other tests that we apply—the acid test and a saponification test. An animal oil under the action of caustic soda will saponify and a mineral oil will not, and we can very simply get the proportion of animal oils blended with hydrocarbon oils.

SOLUBLE FERMENTS.

By J. H. LONG.

UNQUESTIONABLY one of the most important fields of effort in physiological chemistry at the present time is the study of the soluble ferments, and we have here for consideration not only certain newly discovered enzymes, but, perhaps, of more importance, a great advance in our knowledge of those already known. It was not many years ago that we considered the question of the gastric enzymes as practically settled. The presence of both pepsin and rennin no one could have doubted, but the work of Pawlow and his school in the last five years has thrown entirely new light on the subject and it would appear that one and the same ferment, working under different conditions, is responsible for both classes of observed phenomena. Pawlow has compared the digesting and milk curdling power of ferment secretions from the true pepsin and pyloric glands of the stomach, from the pancreas and from Brunner's glands, and has found them perfectly parallel under proper conditions of experiment; any cause which operates to destroy one power, destroys also the other according to Pawlow. But in any given extract or preparation the conditions must be properly chosen to show both effects. A commercial rennet, for example, may exhibit the milk curdling action very strongly, yet appear to be wholly inert toward fibrin. Pawlow holds that in all such cases simple dilution with very weak hydrochloric acid is all that is called for to show the peptic power. A valuable *résumé* of this work is given in a recent number of the Zeitschrift für physiologische Chem. (Vol. 41, p. 415, 1904.)

It is proper to say that the physiologists of the Hammarsten school do not admit the claims of Pawlow, although the doctrines of the latter have been put in very strong light.

To Pawlow we owe, also, the discovery of a new group of ferments which he calls kinases, or activators. The most thoroughly studied of these is the enterokinase which converts the inactive pancreatic juice into an active ferment secretion. As to the value of the other kinases much less is known.

About four years ago Cohnheim described, under the name of erepsin, a peculiar ferment in the intestinal walls which has the power of splitting peptones and proteoses, but not albumins. This discovery grew out of an investigation to determine the fate of the peptone bodies of proteolysis, it being long known that no appreciable amount of these substances appears in the circulation after digestion. A theory grew up to the effect that in the intestinal walls, just before absorption, they were converted back into true albumins. According to the views now advanced by Cohnheim and others this can not be the case to any large extent. The peptones break down with liberation of the carbon and hydrogen excess, which serves as a source of energy, while the nitrogen fractions go over into the form of amino acids, to be further broken down by the liver. This coincides with the view that very little protein is actually needed by the body. On the other hand, it is held by several physiologists that the erepsin katabolism does not go so far, but merely to the production of amino compounds which are ready for a synthesis not yet understood.

If time permitted I should like to go into the question of enzymes in other directions, especially with reference to the work in the liver and the action of the so-called autolytic ferments, the behavior and general importance of which are still very obscure. A large and interesting literature has grown up around the discussion. A word must be said, however, about the important discussion started two years ago by Cohnheim when he announced the relation of two distinct ferments to the oxidation of carbohydrates in the body. The bearing of this on the question of diabetes was immediately recognized and numerous investigations were launched to throw more light on the subject. According to Cohnheim the pancreas furnishes one of these enzymes and the muscle substance the other. One may serve as a kinase or activator for the other and the effect of the two is to facilitate oxidation in the muscles. The subject is immensely important, but the latest studies do not seem to fully confirm all the Cohnheim statements.

In connection with the subject of enzymes reference must be made to the considerable number of papers which have appeared in the last few years on the question of the relation of the ferments to the simple inorganic katalytic agents. Beginning with the work of Tammann published in the Zeitschrift für Physikalische Chemie many attempts have been made to express the velocity of enzyme reactions by equations analogous to those suggested by Wilhelmy for the inversion of sugar. The extended investigations of Tammann led in general to formulas which were more complicated than those corresponding to the simple logarithmic curve. Some of the more recent work, especially that of Henri, has led to more definite results. The whole discussion has been well reviewed by Bredig in volume 1 of the Ergebnisse der Physiologie.

One of the most interesting developments in recent physiological chemistry is in the discussion of theories of immunity and the relations of toxins and antitoxins. As first presented by Buchner, Bordet, Ehrlich, Pfeiffer, and others, these doctrines appeared from the chemical standpoint wholly visionary and intangible, but in the last few years a great change has followed in the attitude of chemists and now some of the phrases of the immunity theory of Ehrlich have become part of the language of organic chemistry.

It was early recognized that toxins and antitoxins act on each other in a manner suggesting combinations in definite chemical proportions, and attempts were soon made to work out the laws of the union. The earlier Ehrlich experiments seemed to point to simple combinations like those between an acid and a base, the union following to complete saturation. It was recognized later, however, in many cases, that the reaction is not complete and that the saturation curve is far from being a straight line. These observations led to various speculations. Ehrlich assumed that in the ordinary toxin mixtures we have certain modified forms known now as toxoids and toxons, which, while non-toxic, have saturating power resembling that of the toxins. Hence the amount of antitoxin added to a toxin solution to destroy its toxicity would have to be sufficient to combine, not only with the real toxin, but with any toxoid or toxon present also; just as in neutralizing free sulphuric acid by sodium carbonate the amount of the latter necessary would have to be increased if some salt decomposable by sodium carbonate, such as alum, is likewise present. In the one case as in the other the simplicity of the reaction would be obscured by complexity of the mixture.

Arrhenius and Madsen, and others following them, have been led also to study these extremely important phenomena and have given a different interpretation. According to the notions of the physical chemists these reactions are more or less perfectly reversible, which certain experiments seemed to prove, and resemble somewhat the union of an alcohol and an acid which combine to reach a condition of equilibrium. They assume for the toxin-antitoxin reaction the perfect applicability of the Guldberg-Waage mass action formulas, and for a number of relations have calculated the value of the constant *k*. It is interesting to note that a number of the leading physical chemists have taken part in the discussion. About a year ago Michaelis reviewed the subject in a long article in the Biochemisches Centralblatt and this has recently appeared in expanded book form under the title, "Die Bindungsgesetze von Toxin und Antitoxin." Michaelis does not accept the Arrhenius work as satisfactory or convincing, and points out several conditions necessary for the applicability of the mass-action laws which do not obtain in the cases in question; for example, the mixtures are not homogeneous and the degree of reversibility is extremely limited, if it really exists.

On the other hand, the doctrine of the toxoids and toxons appears to explain the apparent discrepancies, and in certain mixtures secured in the experiments of Keyes and Sachs, known to be free from these bodies, the toxin and antitoxin combination followed in proportions represented by an almost perfect straight line.

PRODUCTION OF OXYGEN AND OXYGEN LIGHT.

IN a lecture recently delivered before the Association of German Engineers, Mr. R. Mewes gave a description of devices for the production of oxygen and an account of the theoretical principles underlying their construction and of oxygen light. He first considered such results as have been obtained in connection with tests on oxygen incandescent burners, pointing out the differences between the burners designed by Pictet, Nürnberg, and Mewes respectively. In the first-named burner, the gas and oxygen travel in parallel to the longitudinal axis of the burner tube, while in the Nürnberg burner, the stream of oxygen draws the gas into the interior, resulting in a lengthy pointed flame similar to that of the Daniell burners, so that the combustion zone proper does not coincide with the incandescent mantle. In the Mewes burner the gas and oxygen currents are directed at oblique angles toward the blower in such a way that the various streams meet each other as close as possible to the mantles of the blower, thus transferring the combustion to the surface of the latter. Some results of experiments are given in the following table:

Oxygen-incandescent Light.	Consumption of mixture per N. C. hour. (liters.)	Ratio of gas to oxygen.	Observer.	Consumption of oxygen per 1 N. C. hour (liters.)
Nürnberg	0.7	1.1	Prof. Drehschmidt.	.....
Mewes	0.562	1.03	Gas works in Brussels	.....
	0.674	1.28		.....
	0.5	1.32		.....
Dräger works in Lübeck.	.....	.....		0.24

The extraordinary efficiency of oxygen incandescent light, no matter whether mantles or solid glowers are used, has been borne out by conclusive tests. It is only necessary to produce oxygen cheaply, in order to be able to develop oxygen incandescent lighting in an economical manner. As stated by the author, one horsepower hour is able to produce 0.5 cubic meter of oxygen, containing 7 per cent of nitrogen, according to the Prof. Linde process. The price of 1 cubic meter oxygen varies according to the size of the plant, between a little over ½ cent and 25 cents. Prof. Pictet, however, is building an oxygen plant in Wilmersdorf, near Berlin, and hopes to obtain 1 cubic meter of oxygen, containing 50 per cent of nitrogen, at a cost of ⅛ of a cent.

As the old chemical processes are, so far, too expensive to produce oxygen cheaply, and most likely will remain too expensive, there is at present only the possibility of producing oxygen from atmospheric air by liquefying the same and evaporating nitrogen. The author has himself developed a process of liquefying air on the basis of thermodynamical principles, which even in small plants seems likely to allow the production of gaseous oxygen at a cost of ⅛ to ¼ cent per cubic meter.

The author then describes the previous processes by means of the fundamental equation of thermodynamics, showing that a decrease in temperature of only ¼ degree is obtained in the Linde process for 1 atmosphere drop in pressure, whereas according to the Siemens, Mix, and Mewes processes a far greater fall in temperature can be realized for the same drop in pressure. While all the previous processes share the use of back currents (the air drawn in by the compressor being precooled by the expanded exhausted air so as to reduce the temperature continually up to the liquefaction of air under atmospheric pressure at about —190 deg. C.), the temperature is according to the author's process reduced to —197 deg. to —200 deg. by producing a decrease in pressure by means of a suction pump so as to evaporate only the nitrogen. Insulation is of the highest importance for the efficiency of the process. The Siemens process, which is secondary to none from the theoretical point of view, has failed owing to technical difficulties, while the Mix process has not yet been tested.

Up to almost the end of the eighteenth century mathematicians called negative numbers "fictitious" or "absurd." Even so recently as 1799 a mathematical professor in the University of Cambridge wrote a book called "Principles of Alegbra," and argued against negative quantities. Cajori, in his "History of Elementary Mathematics," says:

"Why was the generalization of the concept of number, so as to include the negative, such a difficult step? The answer would seem to be this: Negative numbers appeared 'absurd' or 'fictitious' so long as mathematics had not hit upon a *visual or graphical representation of them*. . . . History emphasizes the importance of giving graphical representations of negative numbers in teaching algebra. Omit all illustration by lines, or by the thermometer, and negative numbers will be as absurd to modern students as they were to the early algebraists."

THE TESTING OF PHOTOGRAPHIC DRY PLATES.*

By C. E. KENNETH MEES, B.Sc.

WHILE there are but few scientific workers who are not more or less expert photographers, few of these possess an adequate knowledge of the laws which define the reactions of the photographic dry plate. This is especially unfortunate in view of the fact that, provided these laws are understood, the photographic plate can be used as an extremely satisfactory instrument for the quantitative investigation of many forms of radiant energy.

The blackness of a developed photographic plate is due to the deposition of large numbers of small grains of metallic silver within a thin film of gelatine. Consequently, the product of the reaction will be expressed in terms of the mass of silver deposited.

There are various methods of obtaining measurements of this mass of silver. One, for instance, is to dissolve out the silver with nitric acid, and, after destroying the gelatine, to titrate the silver with potassium thiocyanate, thus volumetrically estimating the mass of silver per unit area. This method is, of course, tedious, and is quite inapplicable to small surfaces of plate; the mass of silver which gives an ordinary intermediate density, such as stops nine-tenths of the light for instance, being about one milligramme per square centimeter.

On the other hand, it is quite possible to measure the amount of light which the plate stops, and it is clear that this amount will have some relation to the mass of silver present in the plate. This relation, in the form in which it is adopted at present, was originally worked out by Dr. F. Hurter and Mr. V. C. Driffield, and published in May, 1890, in a paper read before the Society of Chemical Industry, entitled "Photochemical Investigations."

The relation is as follows:

If I_o = the intensity of the incident light,

and I_a = the intensity of the transmitted light:

Then, $\frac{I_a}{I_o}$ = transparency = T

$\frac{I_o}{I_a}$ = opacity $O = \frac{1}{T}$

It has been proved experimentally, by Messrs. Hurter and Driffield, and by Dr. Eder in Vienna, that the mass of silver per unit area is proportional to the value termed the "density," and defined by

$$D = \log O = -\log T.$$

In theoretical work these logarithms are taken to base e; in practical work to base 10, as usual.

Thus, in order to measure the product of reaction in a photographic plate, we must measure the transparency, and from this calculate the density. By multiplying the density by a factor termed the "photometric constant," we can obtain the number of grammes of silver per square centimeter.

A density of 0.303 then, will mean that the plate transmits half the light; a density of 1 corresponds to a transmission of one-tenth of the light; a density of 2, to a transmission of 1-100 of the light, and so on. With some of the improved photometers, densities as high as 5.7 have been measured, corresponding with a transparency of 1-500,000 of the incident light.

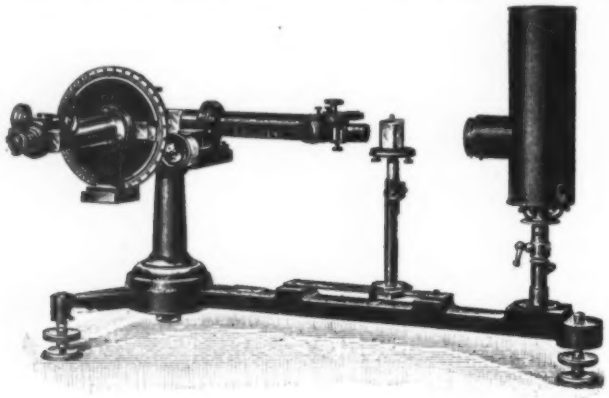


FIG. 1.—HÜFNER SPECTRO-PHOTOMETER.

The instruments used for measuring the density are of several types. Modified bench-photometers, of a type originally designed for measuring the relative brightness of two light sources, have generally been used in England. The Germans, on the other hand, have adopted the "absorption photometer," developed by Vierordt, Glan, König, Martens, and other continental workers, for physiological and physico-chemical purposes.

One of the most efficient of these photometers is the Hüfner spectro-photometer, which is supplied in England by Messrs. Hilger & Co., in an exceedingly practical form. Figs. 1, 2, and 3 show the general appearance of the instrument, and also its elevation and plan.

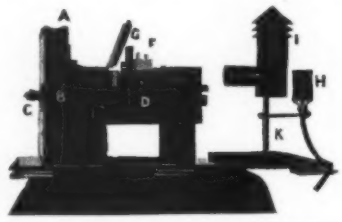


FIG. 4.—EXPOSURE INSTRUMENT.

The method adopted is to obtain two fields, which are spread out into spectra, in juxtaposition in the eyepiece, small patches being isolated by shutters. The top one of these fields is diminished by the density to be measured; the lower one is undiminished, but is plane-polarized by the Nicol's prism, marked *C*.

If, then, the analyzing Nicol *G* (Fig. 2) be rotated, the lower field will be darkened, while the upper field will be unaffected. When equal illumination of the two fields is obtained, the angle through which the analyzer has been turned is read upon the divided circle *H*. Now the intensity of the light transmitted by crossed Nicols is equal to $I_o \cos^2 \theta$, where I_o is the original intensity, and θ is the angle between the polarization planes of the Nicols.

Consequently, as the intensity of the light in the lower field is $\cos^2 \theta$ times the original intensity, and this is equal to the intensity of the light in the upper field, the transparency of the plate placed in front of the upper field is equal to $\cos^2 \theta$, i.e.,

$$I = \cos^2 \theta, \text{ and } O = \frac{1}{\cos^2 \theta};$$

$$D = \log O = -\log (\cos^2 \theta).$$

For instance, if the angle read is 45 deg.,

$$\cos \theta = \frac{1}{\sqrt{2}},$$

$$\cos^2 \theta = T = \frac{1}{2},$$

$O = 2$, and $D = \log_{10} O = 0.303$.

The first result which it would appear desirable to obtain is the relation between the density produced upon any plate, and the exposure which that plate has received.

Occasionally some most peculiar mistakes are made in regard to this relation. It has more than once been assumed, for instance, that the mass of silver produced is directly proportional to the exposure received.

The most satisfactory relation appears to be that given by Messrs. Hurter and Driffield; and the method of sensitometry introduced by them is the basis of a very useful system of expressing the working properties of different plates.

This method is as follows:

A series of graduated exposures are made, in an exposing machine, upon a slip of the plate to be tested; these exposures being obtained by means of a standard light source and some method of graduating the intensity falling upon different parts of the plate in a known manner.

The plate is then developed in a thermostat maintained at a fixed temperature by means of a regulator. The development is effected for a fixed time, by the action of a standard developer. After fixing and washing, the plate is tested by means of the photometer, and the relation of the density to the logarithm of the exposure is plotted upon squared paper.

From the curves thus obtained, the various constants which define the behavior of the plate are calculated.

The procedure is as follows:

The exposure instrument (Figs. 4, 5, and 6) consists of a camera, at one end of which is placed a standard acetylene burner, consisting of an acetylene flame burning at constant pressure, and fitted with a Methven screen in order to insure constancy in the light emitted. This screen consists of a metallic plate pierced with a small hole, so that only that light which proceeds from a small central portion of the flame is used. At the other end of the camera a strip of the plate to be measured (4¼ inches x 1 inch is a convenient size) is placed in a dark slide behind a sector-wheel, which is shown separately in Fig. 7. In this sector-wheel the sectors cut out, proceeding from the middle, are 180 deg., 90 deg., 45 deg. . . . for nine sectors. Each piece of the plate, therefore, receives twice the exposure of the piece immediately preceding it when it is exposed behind this rotating wheel.

A small hot-air engine serves excellently to drive this wheel, and can also be used to stir the thermostat, which is used for development.

The camera is fitted with a flap shutter at *E*, and with cells for containing colored fluids at *F*. In sensitometric experiments, this cell at *F* contains a fluid which is calculated to exactly reduce the spectral composition of acetylene light to that of June daylight. This is very necessary in the case of orthochromatic plates, as otherwise the great excess of yellow and green, as compared with blue-violet, in the acetylene flame, would unduly favor the color-sensitized plate. The iris diaphragm shown at *G* is only used for special experimental work, and not for plate testing.

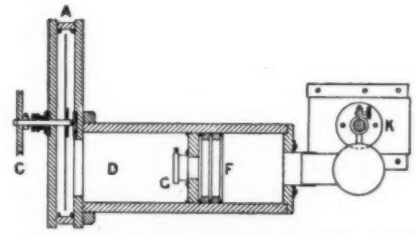


FIG. 5.—PLAN OF EXPOSURE INSTRUMENT.

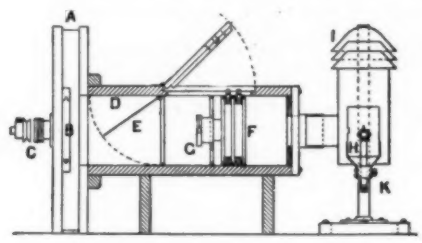


FIG. 6.—ELEVATION OF EXPOSURE INSTRUMENT.

References, Figs. 4, 5, and 6.

A, Guard box for sector; B, open grooves for dark slide; C, driving pulley; D, camera; E, flap shutter; G, removable diaphragm, with iris diaphragm and ground glass for altering intensities, not used at all in practice; H, screened acetylene burner; I, hood for burner; K, stand and slide for burner.

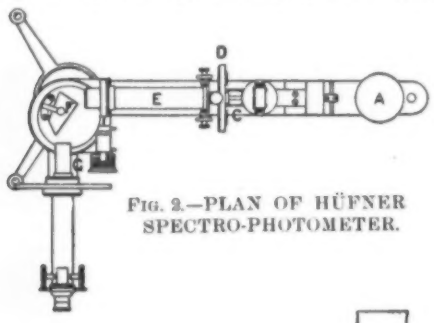


FIG. 2.—PLAN OF HÜFNER SPECTRO-PHOTOMETER.

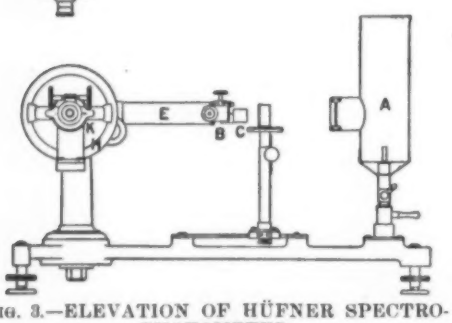


FIG. 3.—ELEVATION OF HÜFNER SPECTRO-PHOTOMETER.

References, Figs. 2 and 3.

A, burner; B, Albrecht rhomb; C, polarizing Nicol; D, Compensating wedge; E, collimator; F, prism; G, analyzing Nicol; H, circle; K, ocular slit.

FIG. 7.—SECTOR WHEEL.

This exposed plate is then developed, as subsequently described, and, after fixation, washing, and drying, is placed in the carrier shown in Fig. 8, which fits in front of the spectro-photometer; this enables one to isolate the little patch to be measured, in front of the upper half of the spectro-photometer front, while the lower beam for the photometer passes through the un-

* Technics.

exposed part of the plate below. Thus the difference in density between the exposed and unexposed portions of the plate is measured. This compensates for any general fog of the plate not due to the exposure.

The carrier is fitted with a spring catch, so that each density is placed in position in the photometer by simply pushing the carrier forward one place.

The development of the plate is effected at a constant temperature by means of a thermostat of the type shown in Figs. 9 and 10. This appliance consists of a large copper tank *A* (Fig. 9), tinned inside, and holding about 10 gallons of water. The water is kept in motion by means of a four-bladed stirrer, driven by a pulley, *E*, from shafting.

Underneath the tank is a flue-box, *B*, through which passes a current of hot air from a Bunsen burner, which is controlled by means of a thermo-regulator (*B*, Fig. 10). The plates are placed in holders, one of which is shown in Fig. 11. This consists of a xylonite sheath, *E*, into which the plate *F* slides. The sheath wedges into the split spindle *C*, which passes through the bearing *B*, and is rotated by means of the pulley *D*. The vulcanite cover, *A*, is the top of the brass developing tubes. Inside these brass developing tubes are stoppered glass tubes, in which is placed the developer. The developer used consists of a decinormal solution of potassium ferro-oxalate, obtained by dissolving 184 grammes of potassium oxalate to make 900 cubic centimeters of solution, and also 27.4 grammes of ferrous sulphate to make 100 cubic centimeters of solution. Ninety cubic centimeters of the oxalate solution, added to 10 cubic centimeters of the ferrous sulphate solution, will then make 100 cubic centimeters of standard developer.

In this way we may obtain a series of densities corresponding with a series of exposures. Now, if we plot the density against the logarithm of the exposure, we shall get a curve of the type shown in Fig. 12. The equation of this curve has been shown by Hurter and Driffield to be of the form:

$$D = \gamma \log (p - (p-1)\, \epsilon^{-\frac{E}{pI}})$$

Here D is the density of the plate, and E the exposure received, and p is the optical opacity (O) of the

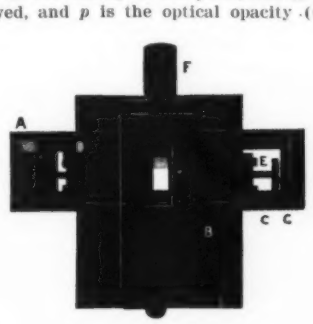


FIG. 8.—CARRIER.

A, Plate carrier; B, spring clicker; C, clicks; E, adjusting screw for side plates; F, top plate; S, springs.

unexposed plate to blue-violet light, I is a constant expressed in the same units as E, and γ is a constant depending on the development.

Now, throughout a considerable number of the points on this curve, a straight line may be drawn, as is shown in Fig. 12.

This straight line will have the equation, of the form $y = mx + l$, which may be written $D = \gamma$ (log E — log i), where i is expressed in exposure units.

It is found, experimentally, that for most plates the value of i is independent of the development, provided that the developer does not contain free alkaline bromide. This value i is called the "inertia," and is taken as fixing the speed of the plate; that is, the greater

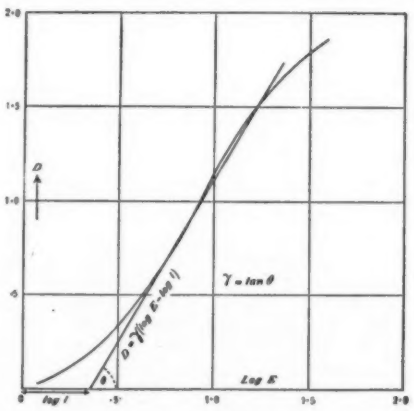


FIG. 12.—CURVE SHOWING RELATION BETWEEN THE DENSITY (D) AND THE LOGARITHM OF THE EXPOSURE (E).

the value of i, the less the density for any exposure E, and consequently the less the sensitiveness of the plate. Therefore, the sensitiveness of a plate is inversely proportional to the value of the inertia.

There are various current methods of expressing this inverse of the inertia. Hurter and Driffield found their "actinograph number" by dividing the number 34 by the number expressing the inertia. Mr. Watkins, for his meters, uses a higher number of about 68, while Mr. Wynne has adopted an inverse method of expressing the sensitiveness in terms of the diaphragm which will give an exposure of one second, under specified conditions of light intensity. Possibly it is most convenient to express the sensitiveness by dividing the inertia into 50. The results so obtained for particular batches of plates might be:

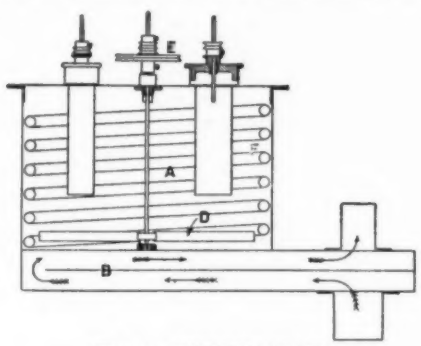


FIG. 9.—THERMOSTAT.

A, Thermostat box; B, flue box; D, central stirrer; E, central pulley; F, cooling coil.

For a lantern plate	1
For a process plate	5
For a Wratten Ordinary	15
For an Ilford Ordinary	40
For a Barnet Ordinary	80
For a Imperial Sovereign	120
For an Extra Rapid	200
For a Monarch, Flashlight, etc.	250 to 400

These figures are merely illustrative; most plates vary in speed from batch to batch.

Besides the sensitiveness of a plate, however, there exists the very important difference which plates ex-

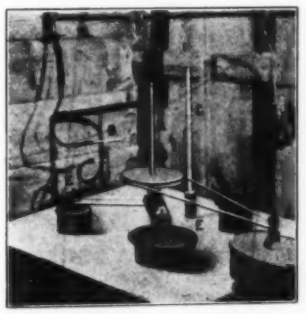


FIG. 10.—TOP OF THERMOSTAT.

A, Central stirrer; B, thermo-regulator; C, thermometer; E, top of developing pots.

hibit with regard to their behavior in the process of development. We have seen that we can express a portion of the plate curve by the straight line equation:

$$D = \gamma (\log E - \log i)$$

where γ was stated to be a factor dependent on development. This γ is clearly tan θ, where θ is the angle which the straight line (see Fig. 12) makes with the log E axis.

If a plate be developed for various times, and measured at intervals, it will be found that at first the reaction progresses rapidly, but that after a short time the amount of density gained each minute becomes less and less, until finally a limit is reached, beyond which no further development is possible, however long the plate be immersed in the developer. On investigation, the reaction of development proves to be a simple heterogeneous one, with the surface of the silver bromide as the variable factor, and to conform

FIG. 11.—PLATE HOLDER.

A, Vulcanite top; B, bearing; C, split spindle; D, pulley; E, plate holder; F, plate.

to the equation for the first order of chemical reaction; in physico-chemical terminology

$$K = \frac{1}{t} \log_{\epsilon} \frac{\gamma_\infty}{\gamma_\infty - \gamma}$$

where γ is the development factor (tan θ) at any time t, γ_∞ is the final factor attained by infinite development, and K is the velocity constant of development.

These facts are set out in the curves shown in Figs. 13 and 14. Fig. 13 shows the slope of the straight line for a plate whose $\gamma_\infty = 2.0$, and $K = 0.2$, for each minute of development from 0 to 13. The gradual approach to γ_∞ will be clearly noticed. Fig. 14 shows the curve obtained by plotting γ against t.

The equation for this curve derived from the above equation will be

$$\gamma = \gamma_\infty (1 - \epsilon^{-Kt}).$$

There is a very simple way of calculating γ_∞ and K from two plates which have been developed, the one for double the time of the other. It can easily be worked out by solving the simultaneous exponential equations; the formula is

$$K = \frac{1}{t_1} \log_{\epsilon} \frac{\gamma_1}{\gamma_2 - \gamma_1},$$

where γ_1 is the development factor attained after t_1 minutes development, and γ_2 is the development factor attained after twice t_1 minutes development. The values of γ_∞ and K are of great importance in fixing the development properties of a plate. Thus, in a plate which has:

High γ_∞ and high K, the image will appear quickly and gain density quickly.

Low γ_∞ and high K, the image will appear quickly, but fail to gain density.

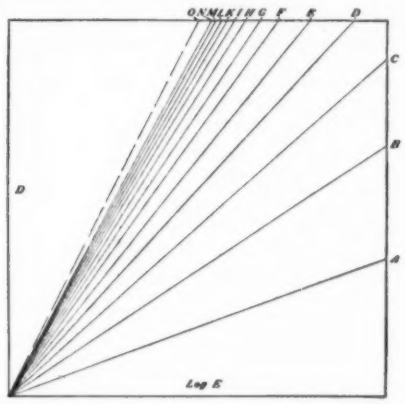


FIG. 13.—DIAGRAM SHOWING RELATION BETWEEN D AND LOG E, FOR VARIOUS CONDITIONS OF DEVELOPMENT.

A.	*Development*,	1 *min.*,	$\gamma = 0.36$
B.	"	2 "	$\gamma = 0.66$
C.	"	3 "	$\gamma = 0\ 90$
D.	"	4 "	$\gamma = 1.10$
E.	"	5 "	$\gamma = 1.26$
F.	"	6 "	$\gamma = 1.40$
G.	"	7 "	$\gamma = 1.51$
H.	"	8 "	$\gamma = 1.60$
I.	"	9 "	$\gamma = 1.67$
K.	"	10 "	$\gamma = 1.73$
L.	"	11 "	$\gamma = 1.78$
M.	"	12 "	$\gamma = 1.82$
N.	"	13 "	$\gamma = 1.85$
O.	"	∞ "	$\gamma = 2.0$

Inertia = 1 K = 0.200

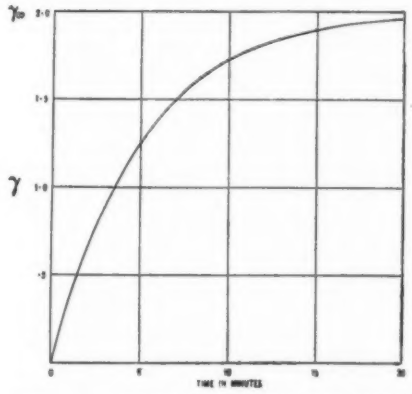


FIG. 14.—CURVE SHOWING RELATION BETWEEN THE VALUE OF γ AND THE TIME.

High γ_∞ and low K, the image will appear slowly, but gain density easily.

Low γ_∞ and low K, the image will appear slowly and fail to gain density.

Since the ordinary printing processes require a γ from 1 to 1.4, the following may be taken as average value of γ_∞:

Low value	1.0
Fair value	1.8 to 2.0
High	2.5 to 3.0
Very high	above 3.0

Process plates and plates used for very short exposures should always give values above 2.5 for γ_∞. In the same way for K, with decinormal ferrous oxalate developer at 20 deg. C., we may expect to get:

For slow plates	about 0.25 to 0.35
For medium plates	about 0.10 to 0.25
For very fast plates	about 0.05 to 0.20

In this way it will be seen that γ_∞ represents the density-giving power of a plate, while K represents the speed of development. Thus, when a maker claims,

in advertisements, for his plates, that they are easy to develop, and have great density-giving power, he means that γ^{∞} and K are both high; of course, it does not follow that it is true, any more than that all plates are the "fastest in the world."

Another factor of importance in plates is their "latitude," that is to say, the range of exposures which they can render in approximately correct gradation. This really means the length of that part of the plate-curve which approximates to a straight line.

It can easily be shown that this latitude is strictly proportional to the optical opacity of the plate to blue-violet light, and, consequently, a measure of this may be included in the sensitometric estimation of a plate.

A high value for the latitude is what a plate-maker means when he states that his plates give good gradation, though the eye-judgment of gradation is usually biased by the value of γ to which the plate has been developed.

In the case of orthochromatic plates, it is necessary to devise some method of measuring their color sensitiveness. This can be done by a series of exposures to the spectrum, but it is by no means easy to deduce any accurate conclusions from spectra, and the method has not the very desirable property of expressing the result as a numerical constant. A much better method is that introduced by Dr. Eder, who exposes two plates, in the exposure instrument, behind two screens, one of which cuts off all the blue-violet, while the other cuts off all the green, yellow, and red; so that the plate sensitiveness is divided into the two parts, blue sensitiveness and chromatic sensitiveness, and the effects of each of these can be compared.

Thus, if the blue inertia is 0.15, and that of the yellow screen is 0.75, then we can express the color sensitiveness by the ratio:

$$\frac{\text{blue sens.}}{\text{yellow sens.}} = \frac{5}{1},$$

remembering that the sensitiveness is the inverse of the inertia. The results for this ratio which may be expected are:

Ordinary plate	100
Erythrosin "orthochromatic," "isochromatic," etc., plate	15 to 20
Panchromatic and orthochrome T plates	5 to 10
Plates with subdued blue sensitiveness	2 to 5
Plates bathed in isocyanines	1.0 to 2.0

Even the best orthochromatic plates are about twice as sensitive toward blue as toward yellow, except one or two comparatively unknown but very useful makes, which are very slow, owing to the almost complete annihilation of the blue sensitiveness by means of yellow dyes, picric acid, etc.

No attempt is made in this article to describe systems of sensitometry other than that employed by the author. For these the reader must be referred to the literature on the subject.

The system employed by Dr. Eder is described in his papers, of which a French translation by M. Belin is published by MM. Gauthier-Villars, under the title of "Système de Sensitométrie des Plaques Photographiques." The system employed by Mr. Chapman Jones will be found in his "Science and Practice of Photography."

The actual practice of sensitometry by the author is as follows: If possible, the plate to be tested is obtained coated on thin "patent plate" glass, and cut into 4 inch x 1 inch and 4 inch x 1½ inch strips, cut in each case from the middle of plates, the edges (where the coating is usually very uneven) being thrown away. If the plates cannot be obtained in this form the strips must be cut from the center of ordinary large-sized plates. Two 4¼ inch x 1 inch plates are then exposed together in the exposure instrument, for a sufficient amount to get all the sectors registered. This amount will vary with the plates. Exposures are measured in candle-meter-seconds—that is to say, the unit is the light of one candle (British standard) at one meter distance for one second. The acetylene standard has been calibrated by repeated careful measurements, so that the exact exposure per second received by a plate at the dark slide is known. In the case of the standard burner used for sensitometry in the author's instrument, the plate receives 3.52 candle-meter-seconds exposure per second, when the sector wheel is removed.

The two plates are next inserted in the holders (shown at *E* in Fig. 11), and two of these are placed back to back in the split spindle. The developer is mixed and placed in one of the stoppered glass tubes in the thermostat, and the whole is left for twenty minutes until the developer has attained the standard temperature.

The plates are rotated in distilled water in the thermostat for one minute, and then placed in the developer, where they are slowly rotated by means of the pulley at the top of the spindle.

After five minutes one is removed, washed for thirty seconds in distilled water and fixed, and after ten minutes the other is also removed, washed for one minute, and fixed. After washing, the plates are measured in the spectrophotometer, and the numbers obtained are plotted as is shown in the curve given in Fig. 12. The inertia, γ_{∞}, and K are then calculated from the values for log *i*, γ_i, and γ_i obtained from the curves.

The opacity of the unexposed plate is then measured in the spectrophotometer for blue-violet light.

After the ordinary sensitometry has been performed for a plate, and the inertia, γ_{∞} and K have been calculated, together with the expressions of inverse inertias as the "sensitiveness" in various systems, and the calculation of the time of development for a factor of 1, which is of use in comparing the developing rate of plates, the color sensitometry of the plate can be proceeded with by means of the 1½-inch plates, as has already been described. Since it is possible in this way to express the properties of a plate in definite symbols, there seems to be no reason (if the common hypothesis, that emulsion making is presided over by the Prince of Evil, be rejected), why much greater uniformity in the manufacture of plates should not be attained.

It would, for instance, be by no means a difficult matter to work out the relation between the value of γ_{∞} and the amount of "cooking" that the emulsion has undergone; or between K and the viscosity of the gelatine. And that done, a sudden drop or rise in γ_{∞} or K should bring instant inquiry into the cause.

In conclusion, the author would express the hope that he has succeeded in making clear the fact that, provided the numerical constants, *i*. γ_{∞}, and K, and the exact curves for a plate are known, and that the plate has been developed in a standard manner, then any one density corresponds with a definite exposure, and can be used as a simple and accurate quantitative measure of that exposure. If this were once generally realized, it is probable that the photographic dry plate would prove an even more efficient scientific instrument than has hitherto been the case.

HIGH SPEED ON STEAM AND ELECTRIC RAILWAYS.*

By ROBERT H. SMITH.

DURING the last two or three years much has been said and written on the subject of increased railway speeds, and the popular vague idea that electricity is to make practicable hitherto unimaginable traveling speeds, since it has actually already produced many things that were unimaginable only a few years back, has infected not a few of our leading electrical engineers. Just recently there has, however, been a lull in the discussion of the main railway problem, as is well illustrated by the particularly cautious reticence in Col. Crompton's reference to it in his James Forrest lecture. He expressed three opinions in reference to this matter, namely, that single-phase current is the only form of electric energy that may have a main-railway future before it, that goods traffic cannot be worked electrically in economic competition with steam traction, and that steam locomotive engineers are likely to greatly improve their machines as soon as there is any serious probability of electric rivalry.

Meantime electrical enthusiasts are gradually learning the general conditions and difficulties of the main-line problem which they propose to attack. A study of these, of which tramway and urban railway work has given them no experience, is necessary for success. A good deal may be already definitely and usefully said as regards the comparison between steam and electric power for high railway speeds.

It must obviously be conceded by all that electric traction has actually raised mean traveling speed upon tramways and upon city passenger railways, and in a very marked degree. Of course, electric traction on such lines has brought with it many other superior conveniences, besides higher speed, which have very largely contributed to their popularity and financial success; but the increase in speed is undoubted and important. But the increased speed is still quite a low speed. On tramways no high speed could be permitted for reasons of public safety. On city railways doubling the present maximum speed would raise the mean speed by only so small a percentage as would yield no profit on the extra cost. The success of the electrification of such lines, in so far as speed is concerned, depends (1) on the density of the traffic; (2) on the uniformity of the service demanded, it being all local passenger traffic and there being no passing of trains devoted to ordinary, express, and goods services; (3) on the very regular and short distances between stops; and (4) upon the regular and very small time interval between trains.

None of these conditions apply to long distance express traveling. Hence it has long since been recognized that this latter problem is an entirely new one absolutely distinct from that already successfully solved on numberless short distance lines. Although Col. Crompton did not actually say so, it is to be presumed that his remarks applied only to long distance runs with either high express speed or at least mixed traffic.

It is important to note that it is only when stations are separated by long distances that very high maximum (as distinguished from mean) speed is of any practical utility, and that in these circumstances very rapid acceleration and retardation become of quite minor importance.

It is not yet certain whether very high express speed between stations far apart is or is not necessarily accompanied by long time-intervals between trains. The determination of this question is of great importance in the solution of the problem. Its determination seems to depend on two things. If it is eventually found that to work a very high-speed service it is essential to set apart isolated lines for this service alone, then this would clear the way for single-coach or two-coach express trains running at small time-intervals. The other plan of clearing the whole line of all other traffic at the times of running the flying expresses naturally leads to the opposite conclusion of making the express time-intervals long and the express trains heavy. Without arguing the matter in detail, it is obvious that the former condition of very frequent and very light express trains is favorable to electric traction, while the other is more favorable to steam traction. Thus the question of long or short time-interval depends largely upon how other conditions will determine the choice of kind of driving power, steam or electric.

Except on the basis of the idea that electricity is capable of doing for us everything that has hitherto been found impossible without its aid, it is difficult to account for the popular expectation of very high speeds resulting from electric traction. Because one of the most remarkable historical facts of the development of electric engineering is that no high traveling speeds have been attempted commercially. The Zossen trials have no flavor of commercial economy about them. If for the sake of pure scientific experiment as much money, trouble and time had been spent upon steam high-speed trials, we would by this time have learned whether 150 miles per hour is possible with steam locomotion. The extreme maximum speeds upon commercial electric lines actually running are only half those on steam lines. So far as historic inference goes, therefore, one should not expect very high electric speeds. This, of course, is not in the least degree conclusive, since steam traction took half a century to grow up to the speeds now reached by electric traction in a life of only a quarter of a century.

The problem of very high speed is, like all truly technical problems, a complex one. It depends on certainly not less than seven factors.

The first of these is, without any doubt, the construction of the roadway. The present high steam speeds have only been reached slowly as the result of rebuilding the road-beds in doubly solid fashion, bedding the sleepers deeper and more compactly, much heavier chairs and rails, and fishplates very much stiffer and better secured. Without this reconstruction the present over-all speed of fifty miles per hour would be impossible, and it is perfectly safe to say that it could not be doubled, or, indeed, raised by any very large percentage (given the same time lost in stops) without entirely new and very expensive reconstruction.

At this first point steam and electric traction seem to be on a par: the question of kind of driving power is simply irrelevant. It may be that electric motors deal more gently with weak rails and a bad road-bed than do steam engines; but to run either at the speeds suggested would equally require rebuilding of the roadway.

This is a very important fact, because it makes it probable that for the introduction of such an entirely new kind of service the building of new and separate lines will be preferred to reconstruction of existing lines, leaving these latter for the ever-increasing local traffic. This is the more likely because for the first ten or twenty years of the new high-speed service, single track would in all probability suffice. Especially would this be so for what may be called single section lines; that is, lines with no intermediate stations between the two termini. Single track express lines between London and Brighton, between Liverpool and Manchester, between Edinburgh and Glasgow, and between Birmingham and London seem already to offer fair chances of remunerative working. Twenty years hence very likely a dozen, or even two dozen, other similar single-section lengths might be profitably suggested. And eventually these would become, linked together, the sections of longer journeys, such as London to Aberdeen, worked upon a rigid block system.

If these considerations be correct, there is little risk in prophesying the adoption of electric in preference to steam traction on such lines. This conclusion is reached, it will be observed, without entering upon the comparative merits of the two kinds of traction *per se* beyond the characteristics already discovered and proved in tramway and city practice. It results directly from these and from the road-bed limit to speed.

The second difficulty in attaining very high speed is the air-resistance to be overcome. At slow speeds this is a small proportion of the total, and through a long range of medium speeds the air-resistance seems to rise as the square of the velocity. Above fifty or sixty miles it probably rises still more rapidly up to some critical speed not yet experimentally investigated, and not revealed distinctly by the published Zossen results. In any case, at extra high express speeds of 100 miles or over, it certainly forms the great bulk of the total resistance. In this second difficulty, again, electric traction appears to offer no direct advantages over its steam rival. With electric motors it may be easier to mold the shape of the car to that of least air resistance than with steam locomotives, but this seems the extent of the superiority that may be claimed on either side.

The hindrance to high speed which is, in the opinion of the writer, third in degree of importance, arises through the spring suspension of the cars and their under frames upon the wheels. Under given conditions of the track, the danger of derailment at high speed depends in a very great and critical degree upon success in insulating the heavy masses lying over the wheels from the shocks arising at the rail surface, and confining these shocks to the comparatively small masses of wheel and axle. The wheels run less risk of riding over the rails in proportion to the quickness with which they are thrust down upon the rails after each such shock. This quickness is inversely proportional to the mass that must be thrust down along with the wheels. The ideal design is to have the tires and wheel rims alone forced to follow the irregularities

* Engineering Review.

of the rail surface and to have everything else spring-borne. In this respect ordinary steam locomotive design is superior to that of geared electric motor tramcars with ordinary nose-suspension. Recently there has been introduced in Switzerland and Italy a type of electric locomotive whose motor gear is coupled to the driving axles by cranks and coupling-rods. In the Ganz cars on the Valtellina line, and in the A. E. G. cars in the Zossen high-speed trials, two different forms of driving mechanism were used which are superior to that of the steam locomotive in this matter of spring suspension. Clearly the attainment of the most perfect construction as regards spring suspension is independent of the choice between steam and electric traction.

The fourth obstacle to very high speed is created by the curves on all our railways. It will be remembered that in the Zossen trials no speed above 170 kilometers, equal to 106 miles, was permitted upon the curve of 2 kilometers = 1¼ miles radius, although double guard-rails extended the whole length of the curve. Here again the whole difficulty arises from centrifugal forces which are exactly the same in steam and electric cars, except that in the latter it may be possible to keep the center of mass slightly lower than in the former. The cure of this hindrance must depend almost wholly on the mechanical design of the roadway. On all new lines now being laid out on which important expresses are to run it is known that nothing above the smallest grade of curvature is being put in. The Langen suspension mono-rail, as seen at Elberfeld, is a theoretically beautiful solution of this difficulty, but at Elberfeld nothing above 40 or 50 kilometers would be safe on account of the want of stiffness in the overhead track girder. This would be rectified by alteration of the design, which was probably intended for nothing over the above low speed, but a girder to carry the suspension mono-rail safely for speeds of 100 miles or more would certainly be extremely expensive, quite independently of curvature.

In the fifth place very large boiler-power is needed on steam trains at high speed on the long runs for which alone high speed is of any utility. The record runs in the United States have been the result of mounting enormous boilers on the locomotives. It is on the boilers far more than on the engines that their practicability has depended. These big boilers, with their great load of water and coal, could only be carried after the entire rebuilding of the lines. In England the tunnels prevent enlarging the cross-section of the boiler in any great degree. The increase of boiler weight aggravates the road-bed difficulty. Here, indeed, electric traction exhibits enormous advantage. Its cars carry no fuel, no feed-water, no store of energy in any form. Furthermore, its driving motors may be distributed over the whole length of the train, and may be applied to every carrying axle, so that the whole load may be utilized for adhesion. In spite of this, the first found decided advantage of electric over steam power, recent proposals for long-distance electric railways pile up upon the motor-car or locomotive a great load of transformers, motor-generators, accumulators, and a second set of direct-current motors.

The reciprocating action of the steam-engine is a second disadvantage for high speed. It produces oscillation, however well-balanced the reciprocating masses may be. The driving strains transmitted on the one hand through the pistons, connecting rods and crank-shaft, and on the other hand equally through the cylinders and side-frames, alternate between compression and tension, and this transmission is through a multitude of joints, at each of which there is a certain inevitable amount of weakness and pliability: at each of the working joints there is some unavoidable slack. Moreover, the joint between the axle-boxes, which are the bearings for the crank-shaft, and the side-frames is a spring joint of great flexibility. When the connecting rod is in thrust and below the center, this spring joint opens; the vertical thrust of the connecting rod through the crosshead on the guide-bar takes part of the load off the springs. On the instroke, when the connecting rod is above the center, the springs are again partially relieved of load because of the connecting rod pull having an upward component acting on the guide-bar. At the dead points the full load comes on the springs. The load on the springs thus oscillates twice per revolution, and the spring joint between axle and frame opens and closes synchronously. Moreover, the two side-by-side engines drive alternately on one and the other side of the machine as a whole, and a lurching motion is the unavoidable consequence. This lurching and the pitching due to variation of load on the springs—the two variations on the two sets of springs at the two sides of the locomotive differing 90 degrees in phase—are unquestionably among the chief causes of the sinuous riding which drives the leading bogie alternately on to the on and the off rail, and thus forms one serious element in the risk of derailment.

On the other hand electric motors drive by a pure torque upon their shafts, and their driving torque is uniform with almost mathematical exactitude. This is the second great item of superiority in electric driving for high speeds.

With a radical reconstruction of the locomotive steam engine, with not less than six, and preferably eight, cylinders, steam traction could, in this respect, be brought more on a par with electric driving; but the present writer does not see how it could be made equally good. Of course a steam turbine might be substituted for the reciprocating engine, but in doing so the accompanying introduction of gearing would deprive the steam drive of the single element of superiority which we have found in its favor.

Lastly it is confidently stated that electric traction gives greater rail adhesion with the same adhesive load. Assuming this to be true, it can hardly be imagined to be due to anything else than the more uniform driving effort exerted, and to the easier spring suspension that has been commonly adopted on tramways. This must cause less jumping and less slipping of wheels on rails, the result of which is that the frictional co-efficient of "rest" is more constantly called into play in comparison with the smaller co-efficient of "motion." Whenever actual jumping on the rails takes place, it must involve the waste of a large quantity of driving energy. The importance of this difference quite certainly rises more and more into prominence with higher speeds.

If the foregoing analysis of the comparison between the two drives as suited for very high railway speeds be correct and cover the most important parts of the ground, it is to be concluded that, while the most fundamental and financially serious obstacles to such speeds are wholly, or almost wholly, unaffected by the choice of kind of driving energy and mechanism, still there are secondary, but also extremely important, differences which tell in every respect except one in favor of electricity—without transformers and without accumulators carried on board.

BACON AND HIS TIME.

By PROF. A. R. FORSYTH.

IT is exactly three hundred years since Bacon published "The Advancement of Learning." His discourse, alike in matter, in thought, in outlook, was in advance of its time, and it exercised no great influence for the years that immediately followed its appearance; yet that appearance is one of the chief events in the origins of modern natural science. Taking all knowledge to be his province, he surveys the whole of learning; he deals with the discredits that then could attach to it; he expounds both the dignity and the influence of its pursuit; and he analyzes all learning, whether of things divine or of things human, into its ordered branches. He points out deficiencies and gaps; not a few of his recommendations of studies, at his day remaining untouched, have since become great branches of human thought and human inquiry. But what concerns us most here is his attitude toward natural philosophy, all the more remarkable because of the state of knowledge of that subject in his day, particularly in England. It is true that Gilbert had published his discovery of terrestrial magnetism some five years earlier, a discovery followed only too soon by his death; but that was the single considerable English achievement in modern science down to Bacon's day.

In order to estimate the significance of Bacon's range of thought let me recite a few facts, as an indication of the extreme tenuity of progressive science in that year (1605). They belong to subsequent years, and may serve to show how restricted were the attainments of the period, and how limited were the means of advance. The telescope and the microscope had not yet been invented. The simple laws of planetary motion were not formulated, for Kepler had them only in the making. Logarithms were yet to be discovered by Napier, and to be calculated by Briggs. Descartes was a boy of nine, and Fermat a boy of only four, so that analytical geometry, the middle-life discovery of both of them, was not yet even a dream for either of them. The Italian mathematicians, of whom Cavalieri is the least forgotten, were developing Greek methods of quadrature by a transformed principle of indivisibles; but the infinitesimal calculus was not really in sight, for Newton and Leibnitz were yet unborn. Years were to elapse before, by the ecclesiastical tyranny over thought, Galileo was forced to make a verbal disavowal of his adhesion to the Copernican system of astronomy, of which he was still to be the protagonist in propounding any reasoned proof. Some mathematics could be had, cumbrous arithmetic and algebra, some geometry lumbering after Euclid, and a little trigonometry; but these were mainly the mathematics of the Renaissance, no very great advance upon the translated work of the Greek and the transmitted work of the Arabs. Even our old friend the binomial theorem, which now is supposed to be the possession of nearly every able schoolboy, remained unknown to professional mathematicians for more than half a century yet to come.

Nor is it merely on the negative side that the times seemed unpropitious for a new departure; the spirit of the age in the positive activities of thought and deed was not more sympathetic. Those were the days when the applications of astronomy had become astrology. Men sought for the elixir of life and pondered over the transmutation of baser metals into gold. Shakespeare not long before had produced his play, "As You Like It," where the strange natural history of the toad which,

"Ugly and venomous,
Bears yet a precious jewel in his head,"

is made a metaphor to illustrate the sweetening uses of adversity. The stiffened Elizabethan laws against witchcraft were to be sternly administered for many a year to come. It was an age that was pulsating with life and illuminated by fancy, but the life was the life of strong action and the fancy was the fancy of ideal imagination; men did not lend themselves to sustained and abstract thought concerning the nature of the universe. We can contemplate the spirit that such a state of knowledge might foster toward scientific learning, and when we recall the world into which Bacon's treatise was launched, we can well be surprised at his far-reaching views, and we can marvel at his isolated wisdom.

I have implied that Bacon's discourse was in advance of its age, so far as England was concerned. Individuals could make their mark in isolated fashion. Thus Harvey, in his hospital work in London, discovered the circulation of the blood; Napier, away on his Scotch estates, invented logarithms; and Horrocks, in the seclusion of a Lancashire curacy, was the first to observe a transit of Venus. But for more than half a century the growth of physical science was mainly due to workers on the continent of Europe. Galileo was making discoveries in the mechanics of solids and fluids, and, specially, he was building on a firm foundation the fabric of the system of astronomy, hazarded nearly a century before by Copernicus; he still was to furnish, by bitter experience, one of the most striking examples in the history of the world that truth is stronger than dogma. Kepler was gradually elucidating the laws of planetary motion, of which such significant use was made later by Newton; and Descartes, by his creation of analytical geometry, was yet to effect such a constructive revolution in mathematics that he might not unfairly be called the founder of modern mathematics. In England the times were out of scientific joint; the political distractions of the Stuart troubles, and the narrow theological bitterness of the Commonwealth, made a poor atmosphere for the progress of scientific learning, which was confined almost to a faithful few. The fidelity of these few, however, had its reward; it was owing to their steady confidence and to their initiative that the Royal Society of London was founded in 1662 by Charles II. At that epoch, science (to quote the words of a picturesque historian) became the fashion of the day. Great Britain began to contribute at least her fitting share to the growing knowledge of nature; and her scientific activity in the closing part of the seventeenth century was a realization, wonderful and practical, of a part of Bacon's dream. Undoubtedly the most striking contribution made in that period is Newton's theory of gravitation, as expounded in his "Principia," published in 1687.

That century also saw the discovery of the fluxional calculus by Newton, and of the differential calculus by Leibnitz. These discoveries provided the material for one of the longest and most deadening controversies as to priority in all the long history of those tediously barren occupations; unfortunately they are dear to minds which cannot understand that a discovery should be used, developed, amplified, but should not be a cause of envy, quarrel, or controversy. Let me say, incidentally, that the controversy had a malign influence upon the study of mathematics as pursued in England.

Also, the undulatory theory of light found its first systematic, if incomplete, exposition in the work of Huyghens before the century was out. But Newton had an emission theory of his own, and so the undulatory theory of Huyghens found no favor in England, until rather more than a hundred years later the researches of Thomas Young established it on a firm foundation.

PRODUCTION OF SALT IN 1904.

THE reported production of salt in the United States during 1904 was 22,030,002 barrels (of 280 pounds), valued at $6,021,222, as compared with 18,968,089 barrels, valued at $5,286,988 in 1903. This is the largest production ever reported except in 1902, but the average net price per barrel (27.332 cents) is lower than that reported in 1903 (27.873 cents) or in any previous year, with the exception of 1902, when the average net price realized was only 23.769 cents a barrel.

The most noteworthy feature of the year 1904 was the increase of 1,193,620 barrels in the production of rock salt. This increase was due in large part to the expansion of the salt industry of Louisiana, where rock salt is easily and cheaply mined in the "mounds" which occur in the southern part of the State.

The chief salt-producing States are New York and Michigan, and the combined output from these two States amounts to about two-thirds of the total production of the United States. The five leading salt-producing States during 1904 were New York, 8,600,656 barrels (39.04 per cent); Michigan, 5,425,904 barrels (24.63 per cent); Ohio, 2,455,829 barrels (11.15 per cent); Kansas, 2,161,819 barrels (9.81 per cent), and Louisiana, 1,095,850 barrels (4.97 per cent).

The actual consumption of salt in 1904 was 23,116,971 barrels, or about 2.46 times what it was in 1880.

The imports of salt in 1904 amounted to 332,279,481 pounds. Great Britain contributed 98,943,611 pounds, worth $301,696; Italy 106,060,288 pounds, valued at $75,756; Canada 11,102,273 pounds, valued at $27,529; West Indies 105,160,371 pounds, worth $89,878; and other countries 20,882,959 pounds, valued at $20,371. The total value of all the imported salt was thus $515,230. It will be observed that while the value of the salt imported from Great Britain was more than 58.5 per cent of the total value of imports for the year, the quantity received from that country was only about 28.9 per cent of the total amount of salt imported. The West Indies and Italy both exceeded Great Britain in the quantity of salt exported to the United States, but it was all of coarse grades, and consequently of low valuation.

During the fiscal year ending June 30, 1904, the movement of exported salt changed notably from the course of trade in the previous year. Exports to Japan dropped off about 38 per cent, probably on account of the war with Russia, but trade with Mexico more than

doubled, and the already large exportation to the Dominion of Canada increased nearly 100 per cent. The total exports of salt during the fiscal year ending June 30, 1904, were 25,508,577 pounds, valued at $99,066, whereas in the year ending June 30, 1903, 16,446,380 pounds were exported at a valuation of $70,296, an increase for 1904 of 55.1 per cent in quantity, but of only 40.9 per cent in value.

FIG. 1.

FIG. 2.

These facts relating to the production of salt in 1904 have been collected for the United States Geological Survey by Dr. Edmund Otis Hovey. They are published for gratuitous distribution, as an extract from the Survey's forthcoming volume "Mineral Resources of the United States, 1904."

DIATOMS, THE JEWELS OF THE PLANT WORLD.*

BY ALBERT MANN.

TO ANYONE familiar with the beautiful plants which form the subject of this lecture it seems strange that so few people know of their existence, for they are abundant everywhere. The evident explanation of this, however, is the extreme minuteness of these organisms, most of which are wholly invisible to the naked eye. Among the 4,000 or more species there is one, *Coscinodiscus rex*, a perfect Goliath among his brethren, which is nearly as big as the head of an ordinary pin; but with this exception, the larger forms can better be compared to the point of the pin, while many are so extremely small that the highest powers of the microscope are needed to display their form and the carvings with which they are ornamented.

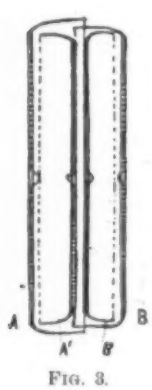


FIG. 3.

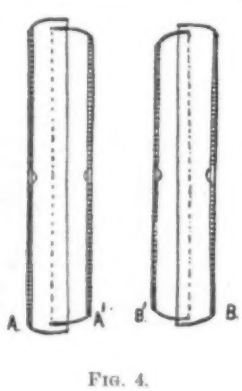


FIG. 4.

The diatoms belong to the group of flowerless, aquatic plants known as the algæ. Where these are divided into six groups the diatoms constitute one of the six; thus (1) Rhodophyceæ, the red algæ; (2) Phæophyceæ, the brown algæ; (3) Chlorophyceæ, the green algæ; (4) Bacillariæ, the diatoms; (5) Heterokontæ, the yellow-green algæ; (6) Cyanophyceæ (Myxophyceæ), the blue-green algæ. I am disposed, however, to classify them as a sub-order in the order *Conjugatæ* belonging to the green algæ, or Chlorophyceæ; and for the following reasons: (1) They have a unicellular thallus, (2) they have large, elaborate and symmetrically arranged chloroplasts, (3) they frequently produce resting-cells with thick walls, (4) they secrete gelatinous masses in which the individuals are embedded, (5) they display a double mode of multiplication, namely, that by fission, or division of one cell into two, and that by sexual reproduction by means of non-motile isogametes. The attempt to classify them with the brown algæ is absurd.

FIG. 6.

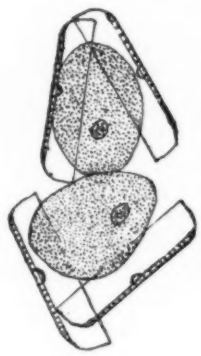


FIG. 7.

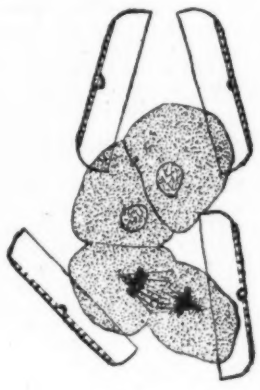


FIG. 8.

The distribution of the diatoms is practically universal. They occupy all waters, torrid, temperate, and arctic; fresh, salt, and brackish; still and running. There is hardly a brook, pond, puddle, lake, river, or sea on earth that is destitute of these plants, unless the water be so contaminated with poisonous matter as to inhibit all life. The largest and most elegant forms belong to the tropics, but the most amazing numbers of individuals are found in the arctic regions. Dr. Nansen found them in undiminished abundance at the northern limits of his polar journey.

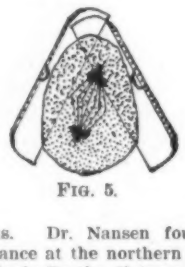


FIG. 5.

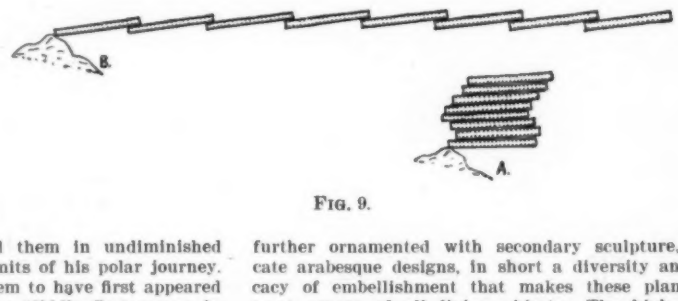


FIG. 9.

Geologically the diatoms seem to have first appeared in the closing measures of the Middle Cretaceous; in other words, they are, though low in organic complexity, comparatively recent in the scale of successive life-forms. The statement of Castracane, that they have been found in the Carboniferous era, and the still more amazing claims that have been made of finding them in Devonian and even Silurian deposits are generally discredited. It should be remarked here that the precise period of entrance of these organisms should be quite clear, because of the prolific multiplication of individuals characteristic of these forms on the one hand and of the indestructible nature of their remains on the other.

Diatom structure can be best understood by looking first at the external skeleton or casing, and then at the living substance within it. Each plant, a unicellular individual, secretes for itself an external case or box of clear and very dense silica, consisting of two valves, an upper and a lower, the one slipping over the other like the lid and bottom of an ordinary pasteboard box, Figs. 1 and 2, *A B*. This case is not of uniform shape; but among the 4,000 or more species there can be found almost every conceivable form, so long as the form displays symmetry on one or both of its axes. Thus there are round, square, triangular, stellate, oval, ovoid, crescent, sigmoid, cuneate, bacillar, etc., forms. It is evident that this great variety in the symmetrical contour of these structures adds considerably to their beauty and attractiveness. The variety is further enhanced by numerous outgrowths in the form of spines, horns, or domes, so arranged as to preserve the symmetry of the valves from which they spring. The two valves themselves, which are with few exceptions identical in shape and markings, are carved and ornamented with an elegance and variety that is well-nigh inconceivable. Indeed it may safely be stated that there is hardly a kind of surface ornamentation known that has not been utilized in beautifying these structures. Polished beads of varying size arranged in radiating or concentric rows, shining bars, wavy ridges, delicate watch-case milling, hexagonal network, the interspaces of which are often further ornamented with secondary sculpture, intricate arabesque designs, in short a diversity and delicacy of embellishment that makes these plants the most ornate of all living objects. The highest efficiency of the microscope is often taxed in revealing some of the minuter markings; and valves that were formerly thought to be quite smooth, and which therefore bear the inappropriate name, "hyaline" or "pellucida," are now under better objectives found to be intricately carved with intersecting lines. It should be here stated that the few illustrations accompanying this description convey no adequate idea of the objects they represent; for in black and white it is quite impossible to reproduce the appearance of these structures of shining silica, often further beautified by prismatic colors refracted from their various surfaces.

Outside of this silica casing there is a very thin and perfectly transparent organic pellicle, in vital connection with the living substance within, erroneously called a gelatinous sheath. It is this internal living substance which determines the position of the organism as a plant, and which presents some of the most

FIG. 10.—*Coscinodiscus asteromphalus*, E., × 185. Sendai, Japan. Photograph by A. A. Adee.

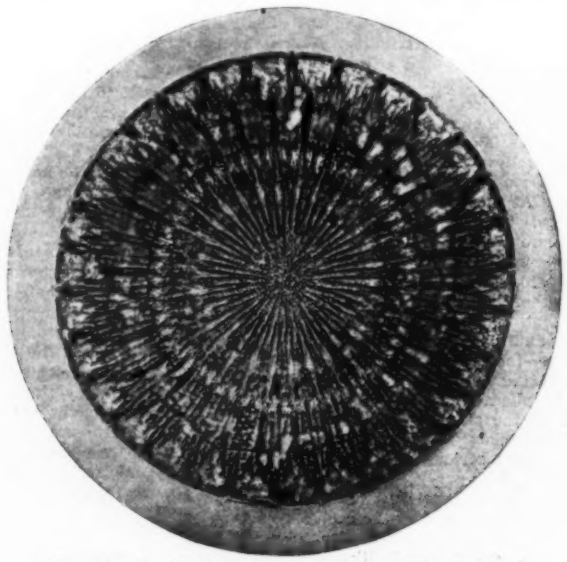


FIG. 11.—*Lepidodiscus elegans*, Witt., × 620. Simbirsk, Russia. Photograph by A. A. Adee

* Delivered at the U. S. National Museum, Washington, D. C., under the auspices of the Washington Biological Society, and published in the Smithsonian Miscellaneous Collections.

interesting problems connected with its life-history. It is made up of normal plant protoplasm (cytoplasm) with a single large centrally-placed nucleus. Rarely there are two nuclei, found only in two or three species where they are said to be constant. Generally there are two larger vacuoles filled with cell-sap, and two or

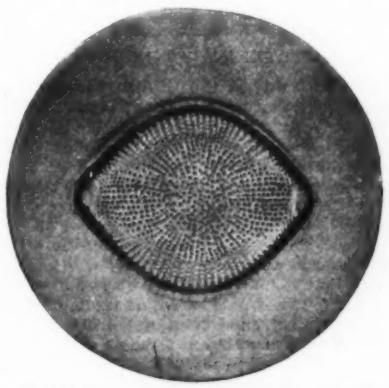


Fig. 12.—*Biddulphia Roperiana*, Grev., variety *mollis*, Mann, × 400. Pacific Ocean, S. S. "Albatross," station 3608.

more chloroplasts. These latter are usually symmetrically arranged, in the elongated diatoms on either side of the median line and in the circular forms in evenly-distributed granules or larger masses radially disposed. The green chlorophyl composing these bodies is disguised by an overlying brown or buff pigment called diatomin, which is so readily soluble in alcohol that when living diatoms are treated with that liquid the diatom instantly disappears and the plants are seen to be

Fig. 13.—*Plagiogramma sceptrum*, Mann, × 375. Galapagos Islands.

bright green. The reserve food material stored up by the diatoms is not in the form of starch grains, but of globules of deep yellow, dense, and highly refractive oil, either floating in the sap of the vacuoles or embedded in the cytoplasm.

Turning now to the physiology of the diatoms the question of their nourishment may be considered. This takes place as in other chlorophyl-bearing plants, by the assimilation of inorganic substances in solution in the water about them through the agency of sun-

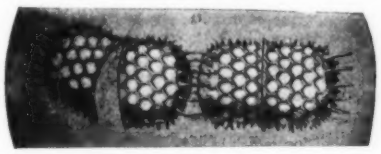


Fig. 14.—*Stephanopyxis ferox*, Grev., × 400. California guano. From Moebius's Plates of Diatoms.

light in conjunction with the chlorophyl masses; and in consequence of this fact it is plain that they are precluded from such waters as are not sufficiently lighted; as, for example, subterranean streams and the deeper parts of the sea. No actual test has been made of the ocean depth at which diatoms can flourish, but the limit is probably something below 100 fathoms. Specimens of diatoms are, it is true, obtained from all depths, even from the abysses of 6,000 fathoms or

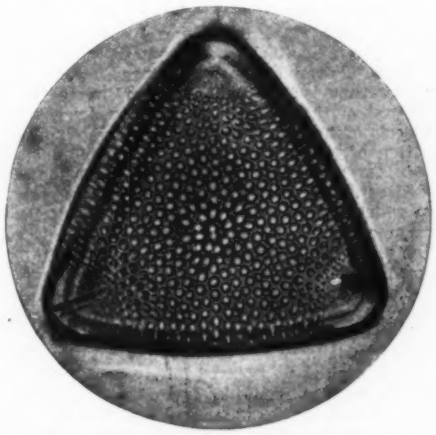


Fig. 15.—*Triceratium* sp.? × 660. Bering Sea.

more; but in such cases they are invariably the dead and empty frustules of plants that have been transported there by surface currents. There are a few diatoms partly or wholly destitute of chlorophyl and which therefore live a saprophytic life. Such is *Nitzschia putrida*, a colorless form, and *Bacillaria paradoxa*, another *Nitzschia*, which is only partly saprophytic and therefore not wholly colorless.

The food-product of assimilation can never be utilized by the individual plant to any great extent; for being incased in an inflexible silica box its chance of growth is restricted to a very slight increase in breadth by the slipping apart of the upper and lower valves or lids; in other words, each diatom is formed at its own maximum length. Most of the reserve food is

Fig. 16.—*Entogonia Davyana*, Grev., × 300 (= *Heibergia Barbadensis*) Barbados. From Moebius's Plates of Diatoms.

therefore utilized in the multiplication of individuals. This takes place in two curious ways. The first and common method is the asexual one of fission, or the separation of a single plant into two along a median dividing line. Although this is the usual method of multiplication in unicellular plants as well as in single cells of multicellular plants, the process in the diatoms is peculiar in taking place, not transversely, that is along the short axis, as is done in the bacteria, the other algæ, etc., but longitudinally from end to end.

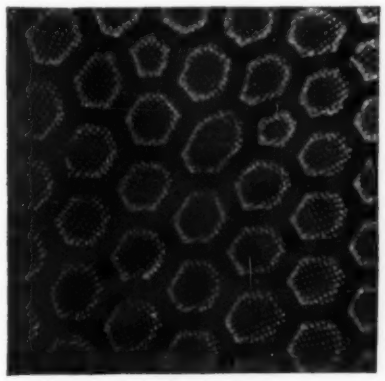


Fig. 17.—Secondary markings within the hexagonal network of *Triceratium favus*, Bright, × 1060. Oamaru, N. Z. Photograph by A. A. Adee.

This peculiarity is the origin of the name "diatom," from $\delta\iota\alpha\ \tau o\mu\epsilon\omega$, to cut through. An examination of Figs. 3 and 4 will make this process clear. It is easy to see that smaller individuals must be formed at each repetition of this process, as the two new valves are always formed within the old ones. The diatom loses approximately one-sixtieth of its length by this method; and if it were continued indefinitely the forms would necessarily dwindle to the vanishing point! This, however, is corrected by means of the second or sexual method of reproduction, a process that brings about two important results: the diatom's vitality is rejuvenated and its ancestral size is restored. This process, called conjugation, may take place in any one of three ways:

1. The nucleus of a single diatom divides karyokinetically; the cell contents swell, bursting apart the valves; the mass passes out into the water, becomes spherical, secretes a large quantity of jelly-like substance; the two daughter nuclei reunite; a large "auxospore" is formed, and within this a single large diatom is built, like the parent frustule, but approximately double the size. See Figs. 5 and 6.

2. The second method is where two diatoms come into contact; the contents swell, as before; the two nuclei remain undivided, but fuse together and pro-

Fig. 18.—Amphora, n. s., × 565. Pacific Ocean.

duce a single auxospore, within which a single diatom, double the former size, is again formed. See Fig. 7.

3. In the third method two parent diatoms join; the nucleus of each divides karyokinetically; the four daughter nuclei unite, the two from one plant with the two from the other, producing two auxospores and giving rise to two large frustules. See Fig. 8.

The first method is common among diatoms that are fixed, and especially those which grow in long filaments. The second is rather uncommon, being confined to a few species. The third is perhaps the most frequent of all and is especially characteristic of the moving diatoms.

Conjugation takes from eight to twenty days for its completion; and as the diatoms lose by each act of fission about one-sixtieth in length, and as they divide every five or six days under normal conditions of nourishment, it would require not more than one act of conjugation yearly to balance the reduction. Frequently conjugation does take place only once in a

Fig. 20.—*Cestodiscus ovalis*, Grev., × 335. Moron, Spain. From Moebius's Plates of Diatoms.

year; and then it is, at least in our latitude, quite uniformly early in spring, often before the ice has entirely disappeared from the streams.

Two other methods of reproduction are claimed as taking place among the diatoms, namely, by means of exceedingly minute spores; and by means of daughter plants, two to sixteen in number, formed within the body of the parent plant. But as the former is wholly unsubstantiated, and the latter, described by G. Murray (in Proc. Roy. Soc. Edin., vol. 21) is, to say the least, most anomalous, no attempt will be here made to describe them.

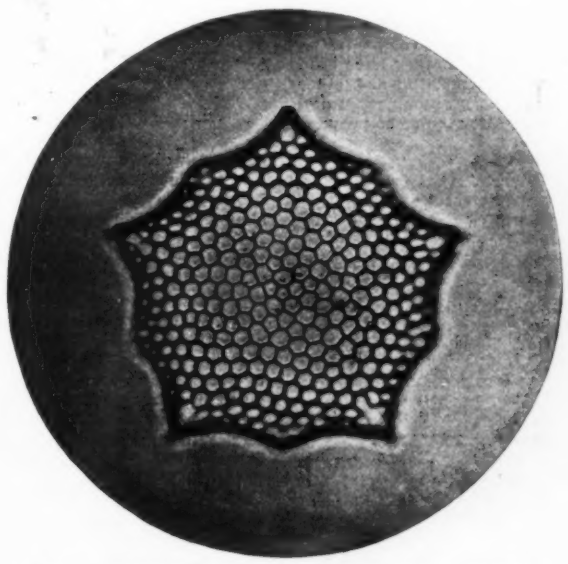


Fig. 19.—*Triceratium Campechianum* Cl., × 720. Florida. Photograph by A. A. Adee.

There is one other physiological process of the diatoms which has up to the present time puzzled all its investigators—their motion. Many of the diatoms grow attached to some support, some of the round and oval forms lying flat on the fronds of other algæ, while

others are fixed at the ends of gelatinous stalks, singly or in clusters, or grow as zigzag chains or in rows like beads or in flat bands as long filaments. But large numbers are free; and these, especially *Nitzschia* and *Navicula*, display a liveliness of motion that is easy to watch but hard to understand. The majority of these forms are boat-shape, and their motion has a stately character quite different from the erratic movements of the lower animal organisms. But these tiny crafts

Fig. 21.—*Actinoptychus Wittianus* O. Jan., × 200. Hayti. From Diatomaceen, Jeremie in Hayti.

move without oar or sail, paddle-wheel or propeller. They apparently present the anomaly of moving without any organ of locomotion! Many theories have been invented to explain this mystery; as fine protruded pseudopodia (Ehrenberg), osmotic currents of water (Naegli and H. L. Smith), rows of cilia (J. D. Cox), a stream of protoplasm moving along the "raphe" a line on each valve, generally in the middle that is thought to be a narrow cleft (Muller). But none of these fit the case. No method of staining known has been able to show any protrusions.* Whatever be the final explanation, it must explain not swimming but creeping; for these organisms are perfectly inert and helpless unless in contact with some fixed surface. This alone disposes of all theories requiring cilia, flagellæ, osmotic currents, etc. The power, too, must be considerable; for diatoms will push aside in their course inert matter many times their bulk. The theory must also apply to the *ends* of the frustules; for the plant will often stand upon end

Fig. 22.—*Brunia japonica*, Temp., × 100. Japan.

and swing about most vigorously. It is not at all improbable that the so-called "gelatinous sheath," which overlies uniformly the entire external surface and is connected with the living cell contents through numerous minute pores, is the seat of this motion, and by undulatory movements over its surface produces the phenomenon that is so evident and so puzzling. Any one who will watch the strange accordion-like extending and retracting movements of those well-named diatoms, *Bacillaria paradoxa*, especially when, fully extended, they touch each other only at the tips and yet form a series as rigid as a rod, will see that some explanation based on the external membrane fits the case better than any other. See Fig. 9, *A* and *B*.

A few words should be said upon the practical uses of the diatoms. The first of these is as polishing powders. Under the name of "tripoli" they have been long in use to give brilliancy to metallic and other surfaces; while, either mixed with soap or put up dry, they are sold under fancy names for the same purpose.

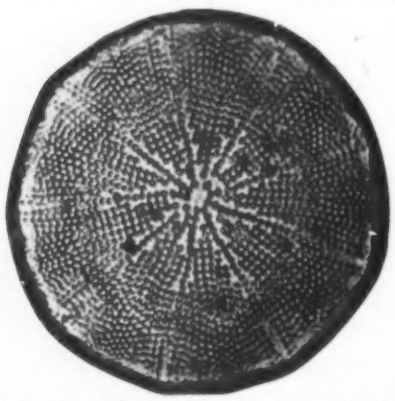


Fig. 23.—*Aulacodiscus* n. s., × 1000. Pacific Ocean, S. S. "Albatross," Station 4029 H.

One widely-known brand of tooth-powder is composed entirely of diatom shells. As an absorbent of nitroglycerine they have been extensively used in the manufacture of various dynamite compounds. They are also employed as a substitute for asbestos in the composition of jackets for steam-pipes, as packing in refrigerators, etc. They have at least a semi-practical use in refuting the utilitarian theory of the origin of species; their rigidly exact yet infinitely diversified carving and ornamentation refusing absolutely to fit into such a conception. Diatoms have a most curious use among the more abject inhabitants of Lapland and Bohemia as a substitute for or an adulterant of food. Under the name of "berg mehl" diatomaceous earth is mixed with flour, fat, etc., and eaten. It is hardly supposable that this fossil earth contains any appreciable amount of nourishment. The philosophy of the practice is probably the fact that where a hungry man has a stomach capacity of two quarts and a food supply of only a pint, he can cajole himself and gain a sense of plethoric bounty by adding three pints of the inert matter to his supply—a sort of "square meal," it is true, but a very hollow one! The diatoms do, however, form a considerable part of the world's food supply, at least in an indirect way; for they are one of the principal sources of nourishment for mollusks, the clams, oysters, etc., whose stomachs always contain large quantities of these plants; as well

Fig. 24.—*Navicula invenusta*, Mann, × 375. Galapagos Islands.

as constituting a good part of the food of small fishes and of the animal organisms on which larger fish feed. Thus they are a sort of primary source of organic food, on the abundance of which many of our most valued food products depend.

It is well to mention here that the diatoms give promise of great practical value in determining the origin of sea-bottoms and the direction and extent of the sea-currents by which they are transported. Their use to applied science in this respect is now being investigated.

There will be no difficulty for anyone interested in the examination of these plants in finding them, either as living or fossil forms. Wherever there is a brown

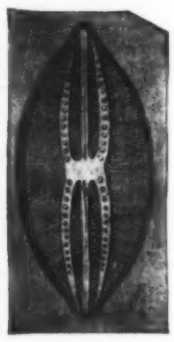


Fig. 25.—*Navicula bullata*, Norm., × 350. Western Australia. From Moebius's Plates of Diatoms.

coloration of the surface of the mud, submerged stones or twigs, not a red-yellow, which is due to iron, but a brown-yellow to almost black, there are diatoms in abundance. It is their characteristic color, when found in masses; and a little of the material placed under the microscope will reveal thousands of them. Or if fossil material is needed, diatomaceous earth can be found in almost every State in the Union and almost every land on earth. Immense beds exist, for example, at Nottingham, Md.; Richmond, Va.; Keene, N. H.; Monterey, Santa Monica, Rodondo Beach, Cal.; near Spokane, Wash.; etc.; while smaller deposits are frequent in many other localities. In foreign lands there are large deposits at Sendai, Japan; Ananino and Simbirsk, Russia; Alicate, Sicily; Bilin, Bohemia; Luneberg, Germany; Mors, Jutland; Oamaru, New Zealand; Springfield, Barbados; etc.

The cleaning of diatoms of organic matter and the preparation of these and fossil forms as permanent microscopic mounts cannot be entered into here. The processes are easily learned from any good work on the microscope.

SPECIFIC INDUCTIVE CAPACITIES OF METALS.—Theory and fact are at variance in the calculation of the resistance of wires for direct and for alternating currents of high frequency. A. Broca shows that the discrepancy can be removed by taking into account the specific inductive capacity of the metal. On doing this he obtains an approximate value for the specific inductive capacity by a new method. Putting it as proportional to the square of the refractive index, he shows that for frequencies between 500,000 and 1,200,000 per second the specific inductive capacity is of the order of 10^{21}. Beyond a frequency of 3,000,000 the specific inductive capacity increases nearly in proportion to the period. Nothing can as yet be said concerning lower frequencies, as no data are available.—A. Broca, Comptes Rendus, June 26, 1905.

DISCOVERIES AT EPHESUS.

IT was announced in the London Times rather less than a year ago that the trustees of the British Museum had obtained a *firman* for the resumption of excavations in the great Temple of Artemis at Ephesus, and had intrusted the direction of the work to Mr. D. G. Hogarth. The site had not been touched since 1874, when the exploration conducted by the original discoverer, the late Mr. J. T. Wood, was brought to an end, and his great pit, coextensive with the platform of the temple, had become an overgrown morass. It has always been felt that his five seasons' work did not lead to final results. In his publication he treated at length of the Hellenistic "Wonder of the World," and he sent to England some magnificent remains of it in the shape of architectural sculpture; but he hardly dealt at all with the earlier temple which he discovered at a lower level, and identified with that to which King Crœsus contributed. The late Dr. A. S. Murray, Mr. Ferguson, and others endeavored to supply the omission by study of the various fragments of architecture and sculpture found by Wood; and quite recently the architect of the Austrian Ephesian expedition, Dr. Wilberg, made a small scale plan and notes of the parts of the early temple surviving *in situ*, so far as they could be discerned amid the dense overgrowth. But more information was obviously required, and to obtain this there must be a fresh clearance. It was suspected, moreover, that Wood's lowest stratum of ruins was not the earliest existent on the site; and it was hoped that not only would architectural remains be found below, but that various small objects might be recovered belonging to all the successive temples, which would supplement the exceedingly meager haul made by Wood, and throw further light on the most important local cult of the great Asian goddess.

The suspicion has been amply justified. There are the remains of two more temples below Wood's lowest, the earliest resting on the virgin sand of the original marsh. The date of its foundation, judged by the numerous offerings dedicated in it and now brought to light, is about the year 700 B. C. The hope that small cult-offerings would be found has also been realized in a very remarkable and unlooked-for way. While the scanty remains of the Hellenistic temple, which served as a quarry for centuries, were found to have been pretty thoroughly explored by Wood, and those of the "Crœsus Temple," which he exposed, yielded little beyond new architectural evidence and architectural sculpture, the strata below proved extraordinarily rich in fine products of archaic Ionian art, inspired in many cases by Egyptian models, but thoroughly Greek in character and workmanship. The earliest antiquities found on the site are essentially Hellenic. If, as has often been believed, there was a pre-Greek, perhaps Lydian or "Hittite," cult of the Great Goddess at Ephesus, her primitive shrine must be looked for elsewhere, probably among the hills south of the plain, where lay the ancient holy place, Ortygia.

The new excavation was begun in the first week of last October, and, with an interruption of three months from December to March, during which some twenty inches of rain flooded the site, was continued into the present summer and brought to a conclusion in the third week of June. After the tangled jungle and the heaps of stones, with which Wood had left the pit encumbered, had been cleared away in the early autumn, little difficulty was experienced in exposing the platform of the great sixth century temple, and making a detailed plan of all that survives of it. But, in clearing out the rectangular structure which stands exactly in the center, and was probably the base of the holy image, Mr. Hogarth perceived that there was at least one temple below, and that the lower stratum would prove even better worth investigation. There was just time before the heaviest rains to search a small part of the central area, and extract a quantity of objects of unique character and value; but the exploration of the rest of the stratum had to be postponed. On resuming, the diggers found themselves flooded out. The whole temple area was a vast pond from which only the highest stones of the Hellenistic stratum emerged. No natural outfall could be made as the pit is far below the general level of the neighborhood, and the only recourse was to pump. A powerful engine was hired from the shops of the Aidin Railway, together with a twelve-inch pump, and this was installed in April, and kept at work till the end of the campaign. While the deep central area with its numerous springs was fenced in and kept more or less dry with smaller pumps and hand labor, the engine lifted the mass of the water and sent it down a channel into the Cayster marsh, and thus with infinite difficulty and under very unhealthy conditions the objective of the exploration was completely attained.

Briefly, the outcome is this. Of the uppermost or Hellenistic temple, that built after the famous arson of Herostratus, hardly any new knowledge has been gained. Its component parts have almost wholly disappeared into the walls of medieval Ayasuluk and into the limekilns, a row of which stood on the north of the pit as grim witnesses to the fate of the world's wonder Parts of two heads and some minor frag-

* Since writing the above, Prof. T. C. Palmer has kindly directed my attention to his article in Proc. Acad. Nat. Sci., Phila., 1898, in which he claims to have stained *Encyonia* so as to indicate fine protrusions from the frustules. I have not as yet been able to verify these processes and can only express the hope they may prove to be of more value in shedding light on this mystery than similar claims of protrusions revealed by staining that have been made by earlier writers.

ments of sculpture will be added to the remains that have long been in the British Museum. For the rest, it was possible only to verify Wood's plan, which was found to be creditably exact in every particular. As for the precedent temple, however, which was begun about 600 B. C., and took two hundred years to build, much that is new has been brought to light. It stood, as Wood said, exactly over the same ground as its successor, and its peristyle and cella corresponded to the later ones, column for column, and almost stone for stone, but its western façade was approached by a more dignified arrangement of steps. The remains of its architectural members, now recovered, will enable a satisfactory restoration to be made of its whole order of columns. Some part has been found of every detail, except in the case of the architraves, not an atom of which remains on the site, probably because their greater rectangular blocks were too valuable to later builders. The net result is to confirm the impression, already derived by students of ancient architecture, that in style and workmanship the "Crœsus Temple" was singularly superior to its successor. One can only wonder why the latter, with its coarse moldings, its exaggerated flutings, and its heavy sculpture excited such enthusiasm in antiquity. What Philo called the "only house of the gods on earth" must have been dependent on the general effect it produced on the spectator at a certain distance, and probably owed much to coloring now lost, and to the height at which it was raised on its *podium*. There are already in the British Museum numerous fragments of archaic sculpture supposed to belong to a storied parapet which ran round the top of the sixth century temple. Some 30 new fragments can now be added and perhaps the subject of the whole can be satisfactorily reconstituted. It seems to represent an Amazon combat—a scene from the legendary history of the shrine itself. No new evidence has been gained in regard to the *columnae caelatae* with which this temple, like its successor, is supposed to have been enriched. The fragments already in the British Museum will remain the only relics of these.

So far Wood's information has been revised and supplemented. Now we enter on discoveries undreamed of by him. Not being supplied with pumping apparatus he satisfied himself too easily that, having reached the foundation clay on which the sixth century structure was based, he had come to the bottom of all things. Immediately under that layer of yellow clay (which shows no trace whatever of being, as he said, composed of the fleeces and charcoal reported by ancient authority) there lies, in fact, the complete ground-plan of a much smaller temple of yellow limestone, paved with highly-polished veined marble. It is entirely contained within the area of the cella of its successor, was divided into three halls or courts at least, and shows no trace of a stylobate or of any columns whatever. In the center of it, as of both its successors, stood the rectangular structure which is supposed to have supported the cult image. This was enlarged and remodeled by successive builders, but it never changed its place. It was the holy spot round which one temple after another was built. The primitive base was the smallest, a rectangle of a singular greenish stone, very soft, and showing octahedral jet black crystals. The lowest courses of this lie nearly a meter below the pavement of the limestone temple, and evidently survive from an earlier temple still. Perhaps this was the only structure of the primitive shrine—a small *naos* surrounded by an open court. No other structure has been found *in situ* below the limestone temple, and any lower pavement has been ripped up and used by the subsequent builders. Indeed, one might reasonably have questioned the existence of this fourth, or lowest temple of all, were it not for the fact that, below the third, or limestone, structure, and in many cases under its actual foundations, occurred the hundreds of small dedicated objects, whose discovery was the chief reward of the renewed exploration of the Artemision.

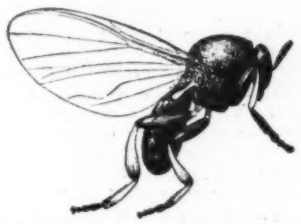
About 500 of these objects were found at the end of the first season, the second season brought over 1,700 more, making a total of well over 2,000. The first hoard was discovered inside the central base. A few electrum coins of very early types, and some paste scarabs served to date the other objects (chiefly of precious metals) to a period anterior to Crœsus. The discoveries of the past spring were made mainly to the west of the base; but the base itself was searched further, and yielded considerable additions to the hoard first found, in the shape of brooches of various kinds, the commonest type being a hawk "displayed," of pendants and beads from broken-up necklaces, of fibulae, hairpins, and charms of one sort and another. The outer region to west yielded less precious metal but vastly more objects in other materials—e. g., in bronze, ivory, rock-crystal, glass, terra-cotta, amber, faience, paste, enameled terra-cotta, wood, and iron. Among these the ivories stand out in respect of style and exquisite workmanship. Statuettes of the goddess, figures of animals, rampant or couchant, plaques, and so forth are the gems of a collection which includes a great number of objects and fragments of less pretension. They represent an art of which we have no other examples. Of the many bronze objects the most notable is an extremely archaic statuette of the goddess in the style of the Hera of Samos; in porcelain there is a group of a kneeling slave with water jar; of the terra-cottas a number of statuettes of the goddess of primitive type, and certain hawks brilliantly enameled. The crystals are many, and mostly in the form of large stud-like objects which may have been pieces of a game. The amber trinkets include a statuette of the goddess. The pastes are, in many cases, purely Egyptian. Over 80 electrum coins, ranging from half-staters down to almost infinitesimal fractions, were recovered in the sieves—they belong to Miletus, Samos, Erythrae and other neighboring cities, and only in a very few instances to Ephesus itself, and are the outcome of the earliest experiments in minting. A silver plate, engraved on both sides in archaic Ionian characters, seems to record treasures of the temple. Two facts in connection with these early objects are obvious and noteworthy; the art which produced them is esentially Greek, and the goddess to whom they were dedicated was not conceived under the gross many-breasted semblance of later times.

The whole makes up a temple treasure quite unique in character, variety, and volume, and precisely dated. Under the Ottoman law its destination is the Imperial Museum in Constantinople; but, as the objects are in many cases duplicated and reduplicated, certain specimens will be granted to our national collection.

EXPERIMENTS IN DESTROYING BLACK-FLIES.*

By CLARENCE M. WEED.

IN certain localities throughout a large part of the United States, black-flies are among the most annoying pests that afflict man and his domestic animals. In some of the Southern States the forms called buffalo gnats often cause the death of cattle, horses, and mules

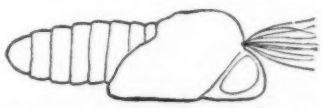


BLACK-FLY GREATLY MAGNIFIED.

to an alarming extent, and at the North the attacks of the northern species are often unbearable. In some of the resort regions of New England these flies are the most vexatious pests that afflict the summer visitor as well as the resident citizen.

No successful method of exterminating these insects has heretofore been known. The only remedies that have been suggested have been various means of preventing or palliating the attacks of the adult flies. The purpose of this bulletin is to describe some successful experiments in ridding a locality of the pests through the destruction of the early stages in their breeding-places.

To understand the practical meaning of these experiments, a brief account of the life-history of these black-



PUPA OF BLACK-FLY, MAGNIFIED.

flies is necessary. The adult flies which annoy man by their attacks go through a series of changes during their growth somewhat similar to those which the mosquito goes through during its development. The flies lay their eggs upon the rocks in the rapids of small streams, especially at the edges of the rippling water. In a short time these eggs hatch into small larvæ that are able to spin a silken web upon the rock to hold them in place. Here they continue to develop until finally they change to pupæ, to emerge a little later as adult flies, often in such numbers that they "drive the fisherman out of the woods, torment the cattle in the pasture, and pester the farmer in the field."

This fact that the black-flies of a locality usually develop in that vicinity, and are comparatively easy to find in their breeding-grounds, offers the opportunity for so reducing their numbers, if we can kill them in their breeding-places, that they will no longer be troublesome.

In the resort regions of northern New Hampshire

LARVA OF BLACK-FLY, MAGNIFIED.

the black-flies have long been recognized as among the most annoying pests for the summer visitors. I have had from time to time appeals from hotel managers for help in subduing the insects, but until recently have had to confess that I knew of no practical solution of the problem. For several years I have had under observation a colony of black-fly larvæ living on the flat rocks of the outlet to our college reservoir, and have often tried to discover effective means of killing them.

When studying the recent literature concerning mosquito remedies, the property of Phinotas oil which leads it to sink to the bottom in water led me to think that possibly here we had an agent for destroying black-fly larvæ. In order to test the theory I sent the assistant entomologist, Mr. A. F. Conradi, in June, 1903, to Dixville Notch, New Hampshire, where these pests have for many years been especially troublesome, with specific instructions to find the breeding-places of the flies, and to try the effect of the Phinotas oil with which he was provided.

The Dixville Notch region was peculiarly favorable as to situation for an extended experiment in subduing black-flies, for it is a comparatively small area surrounded by mountains over which no flies from other localities would be likely to come continuously. A large part of the encompassed area is taken up by a beautiful lake.

Upon his arrival Mr. Conradi made a careful survey of the entire locality, finding no flies breeding in the swiftly-running shaded streams along the mountain sides, but finding vast numbers breeding in the shallow, sunlit waters at the wasteway from the lake and in two or three other places. His notes upon the first experiment with the oil treatment are as follows:

"At the wasteway near the lake dam where the stream is approximately five feet wide, one third of a gallon of Phinotas oil was applied at 4 A. M., June 22. The effect was at once noticeable. At 2 P. M. the same day, most of the larvæ were dead, while the remainder were sluggish. On the afternoon of the next day, the conditions were carefully investigated, and all the larvæ were found to be dead, not only where the oil was applied but for ten feet or so ahead as well.

"The oil was applied by simply pouring it over a shingle, thus scattering it somewhat. It sinks and rises and lingers long about the place. Stones in the water picked up forty-eight hours after the application had a thin film of oil still on them."

When Mr. Conradi reported the results of his trip, it seemed to me that the problem was in part at least solved, the chief perplexing feature being the possible deleterious effect upon fish of the application of the oil in quantity. From the similarity of the breeding-places he found to the one I had been observing, it occurred to me that a little work with stiff brooms in sweeping free the masses of larvæ, and then catching them down stream on wire netting stretched in the water might be helpful where the oil could not be applied. Accordingly, I sent to Dixville Notch a barrel of Phinotas oil and a supply of stiff stable brooms. When these arrived, Mr. Conradi went again with specific directions as to the use of the brooms and the application of the oil, especially, in the latter case, as to the effect upon fish life. He found that the sweeping method was entirely practicable and offered in some breeding-grounds a simple means of destroying the pests. He also found that in a brook three feet wide where in June the flies were breeding in vast quantities, and in which he had poured one gallon of Phinotas oil, the young stages of the flies had been killed off for a distance of one eighth of a mile from the place of application. As regards fish he found that they swam rapidly down stream as soon as it was applied, and apparently were able to escape with no evil results to themselves.

Shortly after the treatment the adult black-flies became so scarce that the hotel manager discarded the smudges which for the past twelve summers had been in daily use for the protection of the guests.

The Phinotas Chemical Company, New York city, furnished in the spring of 1904 two grades of oil for experimental use. One is called soluble oil, and the other is the insoluble oil used last year. On mixing with water the differences between the two are readily seen. The former mixes at once, while the latter sinks to the bottom and gradually rises. I tried both sorts in the water at the outlet to the college reservoir where the black-fly larvæ were abundant. Both appeared to be effective in killing them, but further experiments are necessary to determine which is the better. Very likely under some conditions one may be better, and under others, the other. It is probable that the insoluble oil would be less likely to injure fishes.

It is unlawful in this State to kill fish by the use of any poisonous substance. Consequently care must be taken in the use of oil against black-fly larvæ. An amendment to the law by which town authorities might exterminate the black-flies on their breeding-grounds is desirable. There need be little if any injury to fish, through an intelligent use of the oil remedy. With the sweeping method there is no danger whatever.

The common species of black-fly in New Hampshire as determined through the courtesy of Dr. L. O. Howard of the United States Department of Agriculture is *Simulium venustum* Say.

I believe that these experiments justify the hope that in the near future the black-fly will be more easily controlled in centers of permanent or temporary population than is the mosquito.

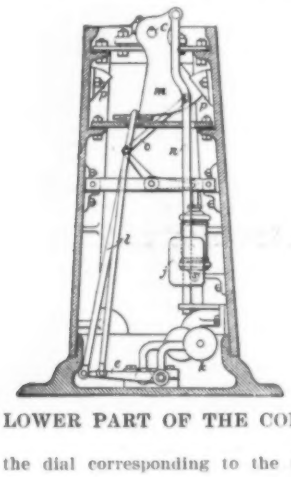
* Bulletin 112 of the New Hampshire College Agricultural Experiment Station.

Mineral Brilliantine.—A product has been patented by M. Chevalot in France, said to cause an instantaneous and permanent brilliancy under the action of ordinary friction, so that wood, to which it is applied, will resist the contact of water without tarnishing the luster. It is prepared by melting 2 grammes of picric acid per liter of pure water, and mixing with it, cold, 2 volumes of silicate for 1 volume of the acid solution, for instance, commercial silicate of soda, having an average density of 35 to 37 deg. Baumé, shaking the mixture of the two solutions in a suitable metallic vessel. The brilliantine may be specially employed for stairways and floors, being applied by means of a flat brush in the direction of the grain of the wood.

AN AUTOMATIC CASK-RECORDING MACHINE.

By the English Correspondent of SCIENTIFIC AMERICAN.

AN ingenious contrivance has been devised by Mr. Thomas Forsyth, of Dublin, for the automatic counting and registering of casks and barrels, and recording the result upon dials or indicators. The most prominent feature of the apparatus is that it will deal with the various sizes of casks, indicating upon as many dials as there are sizes of casks, and as they are passed through the machine it records the number upon the dial corresponding to the size of the barrel.



THE LOWER PART OF THE COLUMN.

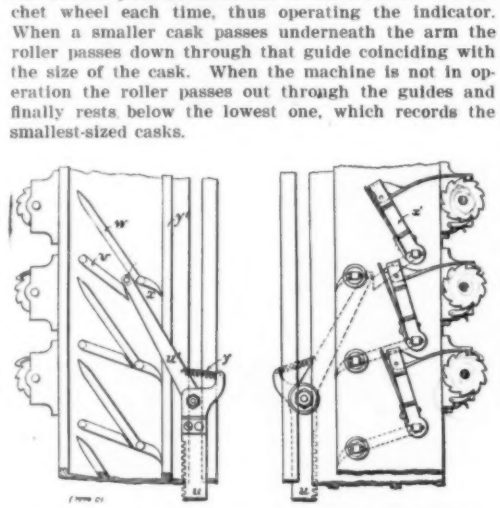
The apparatus somewhat resembles an ordinary weighing bridge in appearance. A pair of narrow-gage rails are laid, along which to roll the barrels. Upon one side stands the recording apparatus, and there is a horizontal shaft extending from this across the rails at a short height above the ground, supported at the other end by a standard. To this shaft is attached another projecting bent arm at right angles. This arm has an upward and downward motion, rising and falling, according to the size of the barrel which passes beneath it. The function of this oscillating arm is to record the barrel passing beneath it upon the requisite indicator. The railroad immediately beneath the horizontal shaft has a locking movement and must be depressed by the barrel before the registering arm can be raised. When the latter is not in use it hangs down, but the passage of a barrel beneath forces it upward directly the rails beneath have been depressed. This latter movement is incorporated as it prevents any possibility of the records being interfered with.

One feature of this contrivance is that every part of the mechanism is placed above the ground, so as to be easily accessible. The registering parts of the mechanism are contained in the side column. In Fig. 1, which is a sectional elevation of the lower section of the column, the recording mechanism is removed, so that the other portions of the working parts are rendered visible. The horizontal shaft which carries the rocking arm is indicated by *c*. *M* is a wrist plate, the upper part of which is extended to carry a rod, *n*, supporting the registering rocking arm. The lower part of the wrist plate is shaped as a quadrant, and the radial sides of this come into contact with the stops, *p*, so as to prevent the registering arm rising too high or falling too low. When the barrel has passed over the locking rails, and has been duly registered by the rocking arm, and the arm has fallen to its lowest point, the balance weights, *k*, cause the locking bars, *L*, to rise and this action prevents the wrist plate from moving until another barrel comes upon the locking rails, and sets the apparatus in motion again. To the lower part of the wrist plate is attached a link, *o*, which transmits the motion of the wrist plate through a lever to a piston in the dash pot. The action of this piston is to regulate the speed with which the registering arm descends. Keyed on to the rigid horizontal shaft is a toothed quadrant, and this transmits the motion of the rocking registering arm to a pinion, which raises and lowers a rack controlling the recording mechanism. All possibility of shock to the stops, *p*, is obviated by fitting them with rubber pads.

Fig. 2 illustrates the recording mechanism in detail and shows the top of the rack. At the under end of this is an arm, *u*, which at its lower end is pivoted, while at the upper end it is free. At this latter end is a pin and roller, which engage in raised guides, *v*, *w*, and *x*. A spiral spring, *y*, holds this arm, *u*, in a backward position and moves with it.

When this rack moves upward through the recording arm being raised by a barrel passing beneath it, the roller at the end of the arm, *u*, travels upward and forward along the sides of the guides, *v*, *w*, and *x*, until it has passed the highest point of the guide, *v*. The spring, *y*, then instantly forces it down to the guide, *v*, or another corresponding to the size of the barrel which is passing through the machine. As the barrel passes through, the registering arm falls, causing the roller at the end of the arm, *u*, on the rack to travel down along the guide, *w*, until it falls into the angle formed by the guides, *w* and *v*. As guide *w* is fixed, guide *v* will open, and the end of the arm, *u*, will pass through, as *v* is pivoted at its upper end. The pivot on which it turns passes through to the back, and has there an arm, keyed at the end of which is a hooked pawl, which engages in the teeth of a ratchet wheel of a rotary counter.

In the event of a number of casks of the same size passing through the machine in contact with each other, the arm, *u'*, descends, and as each cask passes underneath, the roller at the end of the arm passes under and over the guide, *v*, belonging to that size of cask, opening the guide on each downward stroke, and the hooked pawl actuates one of the teeth on the ratchet wheel each time, thus operating the indicator. When a smaller cask passes underneath the arm the roller passes down through that guide coinciding with the size of the cask. When the machine is not in operation the roller passes out through the guides and finally rests below the lowest one, which records the smallest-sized casks.



THE WORKING GUIDES FOR RECORDING DIFFERENT-SIZED CASKS.

We publish herewith a photograph showing in operation the first apparatus that has been constructed. It has been in constant use at a large brewery in Dublin, and it has proved highly successful in action, having registered 13,000 casks with infallible accuracy.

AN AUTOMATIC CASK COUNTER.

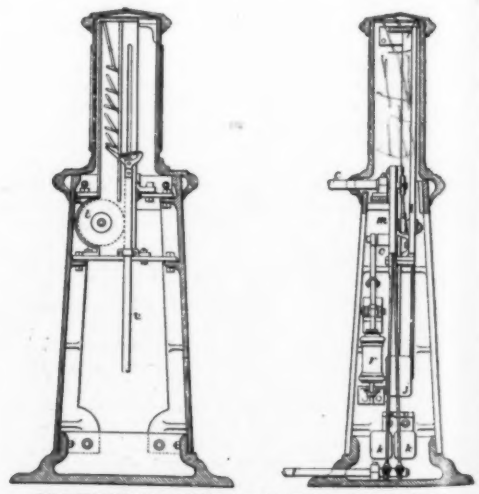
SUBMARINE SIGNALS.*

By SIR WILLIAM H. WHITE, K.C.B.

So far as the German mercantile marine is concerned, as has been announced, it has been virtually decided to adopt submarine signaling extensively in order to increase safety and speed of navigation under circumstances when aerial signals would be practically useless; for example, during fogs or thick weather, when lights cannot be seen, or under atmospheric conditions, when sound signals may be practically useless on certain bearings. It has been long known that submarine signals secure a more rapid transmission of sounds than is attainable through air under the most favorable conditions, the relative speeds being about 4,700 feet per second through water and 1,090 feet through air. In addition, submarine signals are practically uniform in character, and are not subject to interferences such as frequently occur with atmospheric sound signals. Jules Verne, in his "Twenty Thousand Leagues Under the Sea," makes Capt. Nemo of the "Nautilus" dwell upon the superiority of submarine transmission, and there have been many attempts to utilize the principle. Now for the first time a system has been worked out successfully and put into practical form which admits of general use by ordinary seamen. This result is due in part to the utilization of improved electrical microphonic and telephonic apparatus, but chiefly to persistent and long-continued experiments, in which Mr. Millet has taken a leading part on behalf of the Submarine Signal Company. By means of these experiments, which have involved great cost, the investigators have determined the best forms of bells and apparatus for producing sound, the appliances most suitable for receiving and transmitting sounds to observing stations in the interior, when they reach the outside of a vessel, and the best form of telephonic receivers for use at these stations. Care has been taken, too, to provide spare instruments for use in case of accident. The simplicity and compactness of the arrangements illustrate the general principle which has been frequently exemplified—namely, that the most successful inventions are also the simplest in their final form. This result must not be permitted to obscure the merits and perseverance of those who have obtained satisfactory and simple solutions after long-continued experiment.

SIDE ELEVATION OF THE MACHINE.

Up to the present time no corresponding experiments have been made in this country. The matter is receiving favorable consideration from the authorities of Trinity House and the Admiralty. French and Italian naval authorities are also considering the conduct of practical trials. The Cunard Steamship Company are fitting the apparatus in some of their transatlantic steamers, and it is understood that similar action is contemplated by managers of the great steamship companies forming the Atlantic Combine. In regard to navigation generally, in view of the results above described, it is certain that the adoption of a system of submarine signals would add greatly to safety and to the possibility of making good passages under trying conditions of foggy or thick weather. The writer may be permitted to allude to an experience on his return from America last autumn. During the last three days of the voyage before reaching Queenstown, foggy weather was met with, and the captain of the "Lucania" had a period of great anxiety, being entirely dependent upon dead-reckoning and careful soundings. Speed had to be reduced, and the ship had to be stopped to secure more accurate soundings. In the end Queenstown Harbor was made successfully, but after considerable delay, no land having been seen previously. Had light stations on the Irish coast been equipped with bells, and had the "Lucania" been fur-



SECTIONAL VIEWS OF THE MACHINE.

*London Times.

nished with receiving apparatus, she could have kept closer inshore with perfect safety, the sound-signals would have been picked up, the position of the vessel determined, a quicker passage made, and anxiety diminished. For full efficiency of the system, of course, all lightships and stations should be furnished with suitable submerged bells in order that the sounds might be heard at the greatest possible distances. It has been urged that until ships themselves are furnished with bells the system would have only a moderate practical utility. Recent experiments and other observations have demonstrated the fact that if a vessel is furnished with submarine transmitting and receiving apparatus, it is possible to ascertain the approach of another vessel whose machinery is at work, and to locate her direction, while she is still at a considerable distance. These results must be of great value in enabling collisions to be avoided and higher speeds safely maintained in thick or foggy weather. At New York signal bells have already been installed, and vessels which have the new apparatus fitted have proceeded safely into or out of port at good speed, when other vessels not so fitted have had to remain at anchor until the fog lifted. It is stated that the Cunard steamship "Lucania," steaming high speed in a fog, recently heard the Nantucket and Fire Island bells at a distance of four to five miles, and at Sandy Hook at a somewhat less distance.

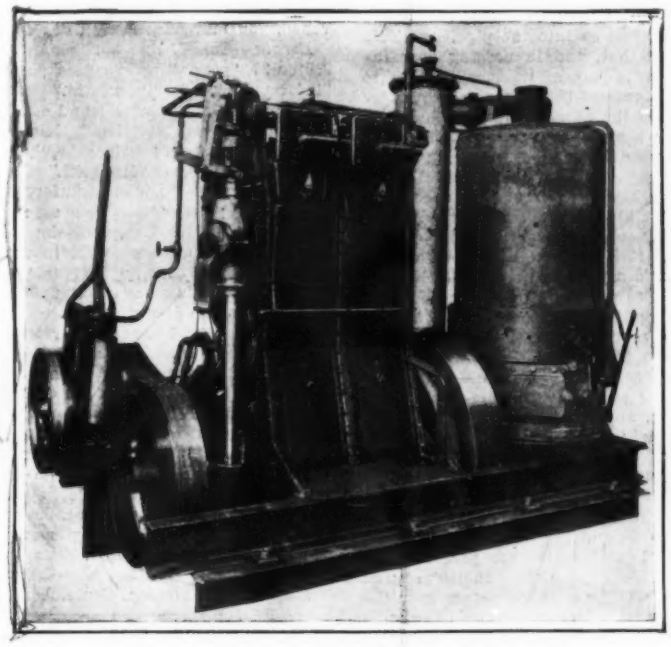
It may be anticipated that this means of increasing the safety of life and property at sea will be very widely adopted before long; and it seems certain that ship owners who take the lead will reap advantages in reduced rates of insurance for their vessels and greater popularity with passengers, since safety will be increased. Further, it may be hoped that the United States and Germany will not long be permitted to maintain the lead of this great maritime country in the practical adoption of submarine signals. Other inventors will probably appear in this field and further substantial improvements may be made, but that is no reason for postponement. The Submarine Signal Company have naturally protected themselves by patenting their arrangements, which are the result of long and costly experiments. Rivals who may enter this field will have to face and overcome many difficulties corresponding to those with which the first investigators have dealt. The success achieved has been in no small measure due to careful consideration and experimental investigation of every detail. It is impossible now to dwell upon this point, although it is both important and interesting. For instance, the design of submarine bells, the determination of their size, form, and tone, the arrangement of mechanisms for striking and the means for maintaining them in efficient order under the various circumstances occurring in different localities, have required extensive investigations. Again, in designing the transmitting and receiving apparatus to be fitted in ships, it has been found possible eventually to make use of simple tanks, filled with a dense fluid, in which the microphonic transmitters are suspended; but it has also been discovered that the relative proportions and dimensions of these tanks have a sensible effect upon the efficiency of the transmitters and the "killing down" of noises within the ship herself, to the extent that permits external sound signals to be distinctly heard at receiving stations. There is no perforation of the "skins" of ships; the sound waves pass through water from a source of sound, impinge upon the iron or steel skin of the ship, are transmitted through the plating to the fluid in the tanks, and so reach the microphonic apparatus, suspended in the tanks, from which they pass to telephonic receivers, which enable observers to distinguish distant external sounds from sounds originating in or near the ship.

For ordinary navigation the apparatus is as applicable to warships as to merchant ships; but the special feature which is now receiving attention in all war fleets is the possible adaptation of submarine signaling apparatus as a means of increasing the power of submarines, or the possible provision in ships threatened by submarines of means for detecting their approach. This opens a wide field for investigation, and it is practically certain that the subject will be experimentally studied by experts without delay.

SECTION THROUGH THE PRODUCER.

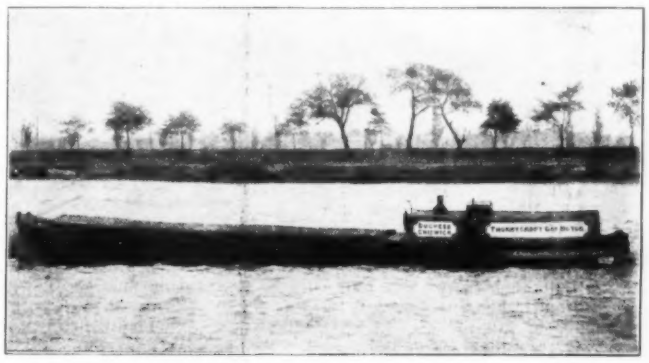
THE FIRST PRODUCER-GAS BOAT.

IT is only within the last four or five years that the suction-producer has been commercially manufactured in England, and in this pioneer work the well-known firm of Crossley & Co. has been, as usual, well to the front, and is now among the best-known makers of this type of apparatus.



THE CAPITAINE PRODUCER AND ENGINE.

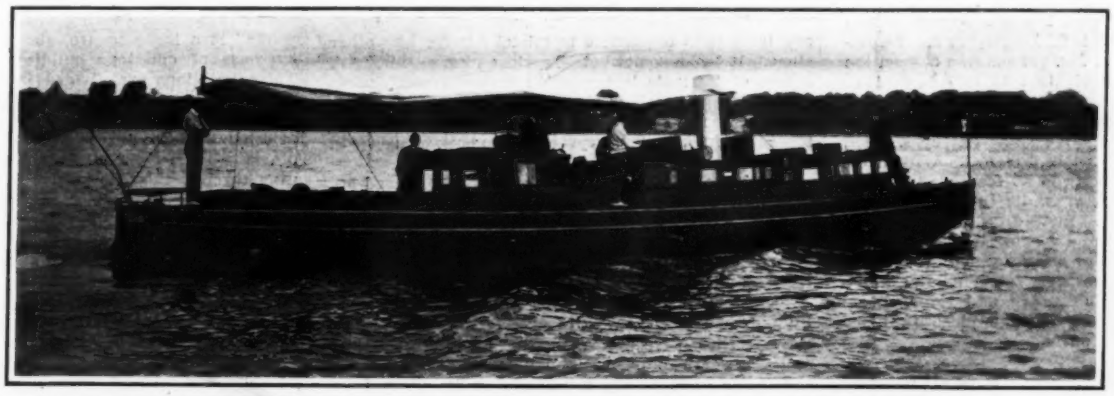
What is probably the first application of a suction-producer to marine work, is due to M. Capitaine, of whose apparatus we are able to give photographs and line drawings. Our first illustration shows the boat "Capitaine," which has been fitted up with a suction-producer plant, and gives a very good idea of how small a boat may be and yet use this class of engine.



THORNYCROFT PRODUCER GAS MOTOR BARGE.

Fig. 2 is a photograph of the complete plant, and Fig. 3 is a sectional elevation through the producer apparatus.

Of these illustrations Fig. 3 gives the most comprehensive idea of the actual gas-making part of the plant, and, from what has already been said, the arrangement of the producer chamber, *A*—shown on the left—will be readily understood. Besides this, however, there are two other chambers, *C* and *H*, which will be referred to presently. The producer chamber, *A*, is fed with anthracite coal through the doors, A^3, but a fire has, of course, first of all to be lighted on the fire-bars at the bottom. The producer is got under way by the



THE "EMIL CAPITAINE," A 75-HORSE-POWER YACHT DRIVEN BY PRODUCER GAS.—THE FIRST OF HER KIND.

aid of a hand-fan, which is used for blowing air through the fire, and the fumes that are given off during the operation are allowed to pass into the atmosphere. Under working conditions, the center part of the producer is a mass of incandescent fuel, and the top part, surrounding the boiler, *B*, is kept filled with fresh coal which replaces the lower layers as they are consumed. In order to prevent radiation the center part of the producer chamber shell is "lagged" with fire-brick.

The gas generated in the producer passes among the tubes of the boiler, *B*, and so into the pipe, A^1. This gas is, of course, very hot, and in passing over the boiler it gives up a large part of its sensible heat to the water, and thus generates the steam necessary for the purposes of making the gas. The steam thus generated passes through a pipe, B^1, to the bottom of the producer chamber, where it is allowed to escape into the hot fuel.

Even after the gas has passed between the boiler tubes, *B*, it is still at a higher temperature than is desirable for satisfactory use in a gas engine, and in order to further cool it it is then passed through a chamber, *C*, where it is caused to give up its heat to the water which is sprayed into the cooler chamber. Baffle plates are arranged, it will be noticed, in this chamber, in order to make the gas take a circuitous path, and so to insure that it shall have time to become thoroughly well cooled. The gas, as it leaves the cooler, is still unfit for use in the engine, for it will, undoubtedly, be damp, and, in all probability, it will have some solid impurities, such as particles of ash, etc., suspended in it. In order to remove these impurities the gas is passed through a mechanically-driven "scrubber," *H*. This device is a centrifugal apparatus which, by whirling the gas at high speed, causes the solid particles, and the water, to be thrown outward, and deposited, so that the gas passes to the engine by the pipe, H^1, in a pure condition. The "scrubber" is driven by a belt which passes over the pulley, H^2, from a corresponding pulley on the engine crankshaft, *A*. Mounted on the end of the "scrubber" spindle is the circulating pump, *K*, which supplies water for the cooler and for the cylinder jackets.

A feature of this particular form of "scrubber" is that the gas is delivered to the engine at a pressure which is slightly above atmospheric. The actual means by which the gas is drawn off from the producer is not, therefore, the suction of the engine itself, but the exhausting effect of the "scrubber." It will be noticed, too, that the cooler chamber and the scrubber have, in themselves, a certain volumetric capacity which does, in effect, act as a reservoir for the gas, and prevents any too sudden changes taking place in the producer chamber owing to rapid increase or decrease of the engine-speed or load.

It must be understood that the gas, as it arrives from the suction producer, is not used in the engine before it is diluted with additional air, sufficient to form an explosive "mixture." This operation is accomplished in the "Capitaine" plant by means of an automatic valve which is designed to compensate for any fluctuations which may be likely to occur in practice, such as, for instance, any increase or decrease in the pressure at which the producer gas is delivered from the "scrubber."

Comparatively few particulars are, at present, available as to the construction of the "Capitaine" engines—which are built in both two and four-cylinder types—but Figs. 2 and 3 show the general lines of a four-cylinder engine of this make. The engine is said to run at a moderately high speed, and the magneto ignition is automatically "timed" by means of a centrifugal governor. The arrangement of the overhead cam-shaft is visible in Fig. 2, and the valve-springs are prominent in Fig. 3. The engine-driven "scrubber" can also be seen in Fig. 2, beneath the exhaust-box, which is supported on brackets secured to the engine casting. The engine is started by compressed air stored in a tank below the floor.

As regards the cost of running, the data available show that a 10-horse-power engine consumes 0.5 kilogramme of coal per horse-power hour, the consumption for 30 horse-power and 100 horse-power plants being 0.4 kilogramme and 0.36 kilogramme respectively. With anthracite at 24s. per ton, the cost on the above consumptions is equivalent to 0.166d., 0.113d., and 0.102d. per horse-power hour for the three types of plant under consideration. The floor space occupied by a 25-horse-power engine is 2.4 feet by 5.8 feet, and the head room required is 3.96 feet. With a 50-horse-power engine the length is 7.9 feet, but the other dimensions remain unaltered, while the weight is increased about 25 per cent. Engines of 25 horse-power have two cylinders, but the 50-horse-power size has four cylinders. It is interesting to note that J. I. Thornycroft & Co. have recently taken up the "Capitaine" marine plant in this country, and developments may, therefore, be expected to take place in home waters.—The Automotor Journal.

Cotton, though a sensitive plant, is of all summer-growing crops of the South about the least affected by ordinary changes in the weather. Its long period of growth, fruiting, and maturity affords it ample opportunity to recover from a number of temporary setbacks. During the protracted season from planting in April to the completion of its harvest in November it is exposed to many varieties of weather, and it seems to endure the bad as well as enjoy the good. Such a thing as "half a crop" is unknown. Statistics show that the crop is seldom curtailed by more than one-fourth or one-third.

Correspondence.

THE EVOLUTION OF THE TELEPHONE.

To the Editor of SCIENTIFIC AMERICAN SUPPLEMENT:

ACCURACY being important to you and your readers as well as to myself, kindly permit me to correct some of the few misprints which appear in my article published in your issue of July 15 last, and also to refer to your footnote thereto. Being on the other side of the Atlantic, and the holiday season having intervened, you may excuse my delay in writing.

Errata.—Col. 2, line 35, "plant," not "plans." Col. 3, line 37, "paper," not "papers"; and line 2 from foot, "informants," not "informant." Col. 4, line 18 from foot, "plate," not "plates"; and col. 5, line 9 from foot, "decisions," not "decision." Elsewhere "S. P.," not "S. R.," as appears twice; "Kuhn's," not "Kuhm's"; and "Manzetti," not "Munzetti."

Your footnote (*) is most unfortunately worded. Referring to your dates, you say: "This covers the period when Mr. Sharp thinks the Reis telephone was exhibited at Kemp's Edinburgh establishment." That is understood, on this side of the Atlantic at least, as reflecting adversely upon the whole article. But the matter does not turn upon what I *think*; it turns upon what I *say* from personal *knowledge*, of the actual Reis telephone I saw at Kemp's in January, 1874, and of persons who told me there that they with others had been present at the exhibition thereof about 1863 at Kemp's.

Your own paper, January 2, 1886, contained Prof. Lawson Tait's letter, which recorded undeniably the fact of such exhibition having taken place at Kemp's, as near as he could remember, about the end of 1862, and at which he was present.

Your anonymous Washington representative's suggestions, printed below my article, need no comment.

W. H. SHARP.

Manor Park, London, September 4, 1905.

[Continued from SUPPLEMENT No. 1551, page 24852.]

DIAMONDS.*

By Sir WILLIAM CROOKES.

WASHING AND CONCENTRATING MACHINERY.

THE fine ground which has passed through the holes in the cylinder, together with a plentiful current of water, flows into the washing pans. These pans are of iron, 14 feet in diameter, furnished with ten arms, each having six or seven teeth. The teeth are set to form a spiral, so that when the arms revolve the teeth carry the heavy deposit to the outer rim of the pan, while the lighter material passes toward the center and is carried from the pan by the flow of water. The heavy deposit contains the diamonds. It remains on the bottom of the pan and near its outer rim. This deposit is drawn off every twelve hours by means of a broad slot in the bottom of the pan. The average quantity of blue ground passed through each pan is from 400 to 450 loads in ten hours. The deposit left in each pan after putting through the above number of loads amounts to three or four loads, which go to the pulsator for further concentration.

THE PULSATOR.

The pulsator is an ingeniously designed, somewhat complicated machine for dealing with the diamantiferous gravel already reduced one hundred times from the blue ground, the pulsator still further concentrating the gravel till the precious stones can be picked out by hand. The value of the diamonds in a load of original blue ground is about 30s.; the gravel sent to the pulsator from the pans, reduced a hundred-fold, is worth £150 a load.

Mr. Fred Kirsten, an employe of the De Beers Company,† made in 1897 the remarkable discovery that diamonds alone, of all minerals contained in the blue ground, adhere to grease, that all others will flow away as tailings over the end of the percussion table with the water. Now, all the sorting (except for the very coarse size) is done by these machines, whose power of distinction is superior to the keenest eye of the native.

The diamond has a peculiar luster, and on the sorter's table it is impossible to mistake it for any other stone. It looks somewhat like clear gum arabic, with a sort of intrinsic luster which makes a conspicuous shine among the other stones.

Sometimes as many as 8,000 carats of diamonds are separated in one day, representing about £10,000 in value.

About two million carats of diamonds are turned out of the Kimberley mines in a year, and by the end of 1904 ten tons of diamonds had come from these mines, valued at £60,000,000 sterling. This mass of blazing gems could be accommodated in a box five feet square and six feet high.

The diamond is a luxury for which there is only a limited demand. Ten years ago, from 4 to 4½ millions sterling were annually spent in diamonds. The last few years there has been no necessity to restrict the supply, and at the mines of the De Beers Company there is no keeping pace with the demand.

Prodigious diamonds are not so uncommon as is generally supposed. Diamonds weighing over an ounce (151.5 carats) are not unfrequent at Kimberley. Nine years ago, in one parcel of stones I saw eight perfect ounce crystals, and one inestimable stone weighing two ounces. The largest diamond from the Kimberley mines weighed 428½ carats, or nearly 4 ounces troy. It measured 1⅞ inches through the longest axis, and was 1½ inches square. After cutting, it weighed 228½ carats, losing 200 carats in the process. The largest known diamond has recently been discovered at the New Premier mine, about 20 miles west-northwest of Pretoria. This mine is of the same type as the Kimberley mines, but much larger in size, and in fact it is the largest known diamantiferous pipe in the world—the pipe containing the "blue ground" along the longer diameter of its oval-shaped cross-section measuring over half a mile, the area of which is estimated at 350,000 square yards. This pipe breaks through felsitic rocks. The diamond, called "Cullinan" from the name of one of the directors of the company, on whose farm it was discovered, weighs no less than 3,025¾ carats, or 9,586.5 grains (1.37 pounds avoirdupois). It is a fragment, probably less than half, of a distorted octahedral crystal; the other portions still await discovery by some fortunate miner. Through this unequaled stone I passed a beam of polarized light in various directions, and could see colors in all cases, the brightest appearing when the light passed along the greatest diameter—about four inches. Here the colors were very fine, but no regular figure was to be seen. These observations show that the diamond is in a state of internal strain.

The clearness throughout is remarkable, the stone being absolutely limpid like water, with the exception of a few flaws, dark graphitic spots, and colored patches close to the outside. At one part near the surface there is an internal crack, showing well the colors of thin plates. At another point there is a milky, opaque mass, of a brown color, with pieces of what may be iron oxide. There are four cleavage planes of great smoothness and regularity. On other parts of the surface the crystalline structure is very marked. The edges are rounded in parts, and triangular markings (depressions) are to be seen. I also noticed square depressions, nearly as sharp and perfect as the triangular ones. Gigantic as is the "Cullinan" diamond, it represents in weight less than half the daily output of the De Beers mines, which averages about 7,000 carats per day.

Next in size to the "Cullinan" comes the one which was found at the Jagersfontein mine. It weighed 970 carats—over half a pound.

I will show you on the screen the relative sizes of some large or famous diamonds.

1. Koh-i-noor, after the second cutting, 106 carats.
2. Loterie d'Angleterre, 49 carats.
3. Nizam of Hyderabad, 279 carats.
4. Orloff, 194 carats.
5. Koh-i-noor, after first cutting, 279 carats.
6. Regent or Pitt, 137 carats.
7. Duke of Tuscany, 133 carats.
8. Star of the South, 124 carats.
9. Pole Star, 40 carats.
10. Tiffany, yellow, 125 carats.
11. Hope, blue diamond, 44 carats.
12. Sancy, 53 carats.
13. Empress Eugenie, 51 carats.
14. Shah, 86 carats.
15. Nassak, 79 carats.
16. Pacha of Egypt, 40 carats.
17. The Cullinan, 3,025 carats.
18. Excelsior, Jagersfontein, 969 carats.

THE DIAMOND OFFICE.

From the sorting room the stones are taken to the Diamond Office to be cleaned in acids and sorted into classes by the valuators, according to color and purity. It is a sight for Aladdin to behold the valuators at work in the strong-room of the De Beers Company. In the Kimberley treasure store the tables are literally heaped with stones won from the rough blue ground—stones of all sizes, purified, flashing, and of inestimable price; stones coveted by men and women all the world over; and last but not least stones that are destined to largely influence the development and history of a whole huge continent.

THE COMPOUND SYSTEM.

One great safeguard against robbery is the "compound" system of looking after the natives. A "compound" is a large square, about 20 acres, surrounded by rows of one-story buildings of corrugated iron. These buildings are divided into rooms each holding about twenty natives. Within the inclosure is a store where the necessaries of life are supplied at a reduced price, and wood and water free of charge. In the middle is a large swimming-bath with fresh water running through it. The rest of the space is devoted to games, dances, concerts, and any other amusement the native mind can desire. In case of accident or illness there is a well-appointed hospital where the sick are tended. Medical supervision, nurses, and food are supplied free by the company.

In the compound are to be seen representatives of nearly all the picked types of African tribes. Each tribe keeps to itself, and to go round the buildings skirting the compound is an admirable object lesson in ethnology. At one point is a group of Zulus; next we come to Fingoes; then Basutos; beyond come Matabele, Bechuanas, Pondos, Changains, Swazis, and other less known tribes, either grouped or wandering around making friendly calls.

The clothing in the compound is diverse and original. Some of the men are evident dandies, while others think that in so hot a climate a bright-colored handkerchief or "a pair of spectacles and a smile" is as great a compliance with the requirements of civilization as can be expected.

The natives are not interfered with in their vari-

* Abstract of a lecture delivered before the South African meeting of the British Association for the Advancement of Science.

† Specification of G. Labram, of Kimberley, for "A Method and Apparatus for Separating Diamonds from Earthy Matters," 24,200/97.

ous amusements, always provided they do not make themselves objectionable to their neighbors. They soon learn that tribal animosities are to be left outside the compound. One Sunday afternoon my wife and I walked unattended about the compound, almost the only whites present among 1,700 natives. The manners of the fold were so friendly, and their smiles so cordial, that the idea of fear vanished. At one part a Kaffir was making a pair of trousers with a bright nickel-plated sewing machine, in which he had invested his savings; next to him a "boy" was reading from the Testament in his own language to an attentive audience; in a corner a party were engaged in cooking a savory mess in an iron pot; further on the orchestra were tuning up, and Zulus were putting the finishing touches to their toilet of feathers and beads. One group was intently watching a mysterious game. It is played by two sides, with stones, and grooves and hollows in the ground, and appears of most absorbing interest. It seems to be universal throughout Africa; it is met with among the ruins of Zimbabwe, and signs of it are recorded on old Egyptian monuments. I wanted to learn it, and an intelligent Zulu player offered to teach it to me in a few minutes. Capt. Dallas, however, with a more accurate opinion of my sharpness than my friend the Zulu, assured me that it would take months of study before I could begin to know anything about it. He had tried for years, and could make nothing of it.

They get good wages, varying according to occupation. The work is appreciated, and there are always more applicants than can be accepted. On entering, the restrictions to which they must submit are fully explained, and they are required to sign for three months at least, during which time they must not leave the compound or mine. It is seldom that a man does not return, once he has lived the life in the compound; some come again and again for years, leaving only occasionally to spend accumulated savings. The most careful men save money, and carry it at intervals to the superintendent to keep for them. Occasionally they ask to look at their savings, which may amount to £30 or £40, accumulated by driblets. They are ignorant of savings banks or interest, and are content if they see their own money in the original rags and papers in which it was handed in. The Kaffir, on demand, must behold his coins just as he handed them in, wrappings and all. Sometimes the superintendent will have as much as £1,000 of savings in his care.

GENESIS OF THE DIAMOND.

Speculations as to the probable origin of the diamond have been greatly forwarded by patient research, and particularly by improved means of obtaining high temperatures, an advance we owe principally to the researches of Prof. Moissan.

Until recent years carbon was considered absolutely non-volatile and infusible; but the enormous temperatures at the disposal of experimentalists—by the introduction of electricity—show that, instead of breaking rules, carbon obeys the same laws that govern other bodies. It volatilizes at the ordinary pressure at a temperature of about 3,600 deg. C., and passes from the solid to the gaseous state without liquefying. It has been found that other bodies, such as arsenic, which volatilize without liquefying at the ordinary pressure will easily liquefy if pressure is added to temperature. It naturally follows that if along with the requisite temperature sufficient pressure is applied, liquefaction of carbon will take place, when on cooling it will crystallize. But carbon at high temperatures is a most energetic chemical agent, and if it can get hold of oxygen from the atmosphere or any compound containing it, it will oxidize and fly off in the form of carbonic acid. Heat and pressure therefore are of no avail unless the carbon can be kept inert.

It has long been known that iron when melted dissolves carbon, and on cooling liberates it in the form of graphite. Moissan discovered that several other metals, especially silver, have similar properties; but iron is the best solvent for carbon. The quantity of carbon entering into solution increases with the temperature.

For the manufacture of—I am afraid I must say an infinitesimal—diamond, the first necessity is to select pure iron—free from sulphur, silicon, phosphorus, etc.—and to pack it in a carbon crucible with pure charcoal from sugar. The crucible is then put into the body of the electric furnace, and a powerful arc formed close above it between carbon poles, utilizing a current of 700 amperes at 40 volts pressure. The iron rapidly melts and saturates itself with carbon. After a few minutes heating to a temperature above 4,000 deg. C.—a temperature at which the iron melts like wax and volatilizes in clouds—the current is stopped, and the dazzling fiery crucible is plunged beneath the surface of cold water, where it is held till it sinks below a red heat. As is well known, iron increases in volume at the moment of passing from the liquid to the solid state. The sudden cooling solidifies the outer layer of iron and holds the inner molten mass in a tight grip. The expansion of the inner liquid on solidifying produces an enormous pressure, and under the stress of this pressure the dissolved carbon separates out in transparent forms—minutely microscopic, it is true—all the same veritable diamonds, with crystalline form and appearance, color, hardness, and action on light the same as the natural gem.

Now commences the tedious part of the process. The metallic ingot is attacked with hot nitro-hydrochloric acid until no more iron is dissolved. The bulky residue consists chiefly of graphite, together with translucent chestnut-colored flakes of carbon, black opaque carbon of a density of from 3 to 3.5, and hard as diamonds—black diamonds of carbonado, in fact—and a small portion of transparent colorless diamonds showing crystalline structure. Besides these, there may be carbide of silicon and corundum, arising from impurities in the materials employed.

The residue is first heated for some hours with strong sulphuric acid at the boiling point, with the cautious addition of powdered niter. It is then well washed and for two days allowed to soak in strong hydrofluoric acid in cold, then in boiling acid. After this treatment the soft graphite disappears, and most if not all the silicon compounds have been destroyed. Hot sulphuric acid is again applied to destroy the fluorides, and the residue, well washed, is attacked with a mixture of the strongest nitric acid and powdered potassium chlorate, kept warm—but not above 60 deg. C., to avoid explosions. This treatment must be repeated six or eight times, when all the hard graphite will gradually be dissolved, and little else left but graphitic oxide, diamond, and the harder carbonado and bort. The residue is fused for an hour in fluorhydrate of fluoride of potassium, then boiled out in water, and again heated in sulphuric acid. The well-washed grains which resist this energetic treatment are dried, carefully deposited on a slide, and examined under the microscope. Along with numerous pieces of black diamond are seen transparent colorless pieces, some amorphous, others with a crystalline appearance. Although many fragments of crystals occur, it is remarkable I have never seen a complete crystal. All appear shattered, as if on being liberated from the intense pressure under which they were formed they burst asunder. I have singular evidence of this phenomenon. A fine piece of artificial diamond, carefully mounted by me on a microscope slide, exploded during the night and covered the slide with fragments. Moissan's crystals of artificial diamond sometimes broke a few weeks after their preparation, and some of the diamonds which cracked weeks or even months after their preparation showed fissures covered with minute cubes. This bursting paroxysm is not unknown at the Kimberley mines.

On the screen I will project photographs of artificial diamonds manufactured in the manner described. So far, these specimens are all microscopic. The largest artificial diamond is less than one millimeter across.

These laboratory diamonds burn in the air before the blowpipe to carbonic acid. In luster, crystalline form, optical properties, density, and hardness, they are identical with the natural stone.

In several cases Moissan separated ten to fifteen microscopic diamonds from a single ingot. The larger of these are about 0.75 millimeter long; the octahedra being 0.2 millimeter.

(To be continued.)

ENGINEERING NOTES.

The economy in burning fuel is a matter requiring great skill and experience, and depends entirely upon the evenness, thickness, and condition of the fire, which controls entirely the air supply and, therefore, the perfection or imperfection of the combustion. There is very little use in "splitting hairs" over a quarter of a pound of steam consumption of the engine, while the fireman may be losing ten times this quantity of fuel from inefficient boilers or poor firing.

An old method of balancing the end thrust of centrifugal pumps was by false vanes located upon the outside of the side plates of an inclosed impeller, these being designed to relieve the pressure upon the outside of such impellers, by establishing a counter-flow through the space around the periphery of the impeller and causing a partial vacuum to exist. By making these false vanes of different radial lengths on the opposite sides of the impeller, the end thrust can be counteracted for any given set of conditions, but it is not believed that a pump thus provided with balancing vanes will remain in good operative balance if the original conditions are changed.

The Mallet compound locomotive of the Baltimore & Ohio Railroad has given good service during its work on the heavy grades and curves of the Connellsville division, says the Engineering Record. It weighs, with tender, 479,500 pounds, nearly 200,000 pounds less than two of the heaviest freight consolidation engines used on this division. The drawbar pull of the two consolidation engines is about 79,400 pounds, while that of the Mallet locomotive is 74,000 pounds when working compound and 84,000 pounds when working simple. The train that can be taken up the mountains by the Mallet locomotive and one of the consolidation type is 50 per cent greater than the train that can be handled by two consolidation locomotives. The Mallet engine has one engineer and one fireman, and the comparatively complicated details of its construction, with which the engineer must be familiar to get the best work from it, have apparently caused no trouble.

The diffusion vanes, which form a distinguishing feature of the turbine type of pump, are located in the usual volute chamber of the centrifugal pump in such a manner as to convert the water leaving the impeller at a high tangential velocity into a direct radial flow. This has the effect of overcoming the eddies formed by the water leaving the impeller, thereby reducing the excessive internal friction. This construction therefore causes a centrifugal pump to assume the conditions of a turbine water wheel. The direct radial flow becomes of great importance in compound centrifugal pumps where the liquid being pumped is to be passed from one impeller to another. Many different forms of these diffusion vanes have been devised, and John Richards seems to have been the first one to form these diffusion vanes in a removable annular ring surrounding the impeller, and as these parts are subject to considerable wear, their removal and replacement are thus rendered convenient and inexpensive.

SCIENCE NOTES.

Here on the threshold of the new century we are confronted with the question "What is electricity?" and the answer implied by the question seems to demand a something which could be described by one who knew enough, as one would describe some new mineral or gas or thing. Some eminent scientific men are befogged by the question, say it is some ultimate unknowable thing, and hopeless as an inquiry. If it be a something it must be described by its constant properties as other things are. If it be unlike everything else then it cannot be described by terms that apply to anything else. All material things have some common properties. A glowing coal is an incandescent solid, a flame is an incandescent gas, but neither glow nor flame exists apart from the matter that exhibits the phenomenon. Both are conditions of particular kinds of matter.

In 1877 water was taken from Lake Tegel by means of twenty-five wells having a double envelope of masonry. The space between the jackets was filled with coarse gravel, increasing in size from the exterior to the center. The bottom was from 12 to 20 meters under the lowest level of the aqueous sheet. The water, limpid at the outset, was after six months of exploitation clouded in the reservoir of Charlottenburg and in the pipes. The deposits, brown and ferrous, revealed the existence of an *oxidule* (diminutive oxide) of iron, and of a special alga in certain of the waters, the *Crenothrix polyspora*. This alga was the consequence of the presence of iron. By causing the enrichment of the iron in oxygen, by extensive contact with the air, by means of a stream in cascade, the results reached were satisfactory. The iron in insoluble form was retained on the surface of the filter. The water became limpid again, and the reservoir was freed from the *Crenothrix polyspora*. Berlin has, therefore, adopted the deferrification of the subterranean waters, which are coming more and more into use.

It may be said that present-day physiology, even more than any other section of biological science, is fundamental. Many phases of pathology, ecology, phylogeny, and experimental morphology, especially, may not be clearly differentiated as sections. Broadly conceived, plant physiology concerns itself: 1. With the relationships of existing organisms, ontogenetically and phylogenetically. Phylogeny would necessarily claim much of this general field, as would also morphology, ecology, and other subdivisions. 2. With the functions or activities of organs, tissues, and cells, and the interactions and interrelations of these one with another and with external forces. It is here that morphology touches physiology most closely and here experimental morphology must have its basis. 3. With the incorporation and excretion of matter, metabolism and growth, the sources and uses of energy, irritability, and the minute constitution of living matter. In this last are included many of the most fundamental problems, not necessarily problems involving the question "What is life?" but problems concerned with the resolution of those factors and an intimate knowledge of those materials which make life possible.

Le Bois describes the results of experiments conducted to ascertain the most advantageous period for felling trees for timber. Four beautiful pines of the same age were selected, growing on the same soil and equally healthy; they were cut down in the same way, one at the end of December, another at the end of January, a third at the end of February, and a fourth at the end of March. They were squared in the same manner, made into similar beams, and dried under identical conditions. When examined for their resistance to flexion, it was found that the pine felled in December supported, without change of form, a load twice as heavy as the one felled in March. There was the same difference in the durability. Piles made of branches cut in December were still healthy at the end of sixteen years, while others, made of similar branches cut in March, broke without effort at the end of three or four years. The wood felled in December was also less porous, allowing less moisture to penetrate. Of four oaks felled successively in December, January, February, and March, four identical disks were taken for forming the bottom of vessels of the same dimensions. The four vessels were filled with water to the same height; but while at the end of two hours water filtered through the oak disk of the tree cut in March, the disk of the December oak did not allow a drop of water to pass. The same experiment was conducted with oak casks. At the end of a year the one had lost only 40 cubic centimeters, while the other had allowed 7½ liters to pass. It is therefore desirable to fell wood in December, and to select for purchase winter wood in preference to spring wood. Winter wood is readily recognized from its containing particles of starch, which have the property of becoming blue on contact with tincture of iodine. A little of the tincture is spread on a sample, and if the wood retains its color, or if it merely become darker with the application of the iodine, it is spring or summer wood; if, on the contrary, it become blue, it is winter wood.

TRADE NOTES AND RECIPES.

Coatings for Iron and Zinc.—It is advisable that articles made of iron should first be coated with linseed-oil varnish. It dries slowly, hardens, and enables the operator afterward to exercise an effective control over the condition of his material. Iron must be absolutely dry and free from rust when it is to be painted. It is best to apply next a coating of hot linseed oil; when dry this should be followed by a priming of pure red lead in good linseed oil, and the iron should then be painted as desired, using ground oil-paints and leaving an interval of a week between each coating. Cementing should be done after the red-lead priming, but the last coating must not be given until the whole is thoroughly dry. Bright oil-paints and an upper coating with plenty of oil resist the effects of heat better than thin coatings; moreover, rust can be detected in its early stages with the former. Coatings of tar and asphalt (asphalt dissolved in turpentine) are practicable for underground pipes, but are not adapted for pipes exposed to the air, as they are quickly spoiled. Asphalt varnish, used for coating coal scuttles, fire screens, etc., consists of asphalt dissolved in linseed oil varnish. Iron stoves and stove pipes are best coated with graphite. For the oxidized surface of zinc, either inside or outside the building, we can recommend a coating of silicate, composed of 750 grammes oxide of zinc and 1 kilogramme of soluble glass, and tinted, as may be desired, with mineral color, English red, Siena earth, German black, umber, or ocher. The colors for tinting are ground in water to form a thick paste, and the silicate added. When thoroughly dry (after 24 hours), it is no longer soluble in water. It is not adapted for greasy or acidiferous surfaces or for old coatings of oil-colors. As the paint speedily begins to dry, only small portions of the surface should be treated at a time. Water may be added at the first coatings; at the third, pure silicate should be used. An interval of at least 24 hours is necessary between each coating to allow the paint to dry. Silicate paint can be kept in a cool place for 24 hours. For a triple coating of a surface of 10 square meters, 2.5 kilogrammes of silicate and 2 kilogrammes of zinc oxide are required. In order that the other coatings on zinc may adhere, it is advisable to oxidize the surface by treating with dilute acid or polishing with fine sand and pumice, to use zinc oxide for the priming, and fat but well-drying oil or varnish, which has been allowed to dry for three days at a temperature of 70 deg. C., for the final coating.—Maler Zeitung.

To Render Articles Non-Porous Before Metalizing.—Certain substances, which from their composition might be immediately metalized with graphite, require a preliminary treatment, because, being porous, they would absorb the copper solution, and consequently be spoiled. Among these substances are carbonate of lime (chalk or marble), sulphate of lime (gypsum), wood, and spongy substances, and these must be rendered non-porous to some extent before being plated with metal. This is done either by covering them with a scarcely perceptible coating of varnish or steeping them in wax, tallow, or, still better, in stearine. We will, as an example, describe the treatment of a gypsum or plaster of Paris relief. The object must first of all be fastened to a sufficiently long brass wire. This wire is wound in a groove in the edge or attached to the article in some other way, but so as to leave a long end free. The article is then plunged into melted stearine, kept at a temperature of 80 deg. to 100 deg. C., when a quantity of bubbles will immediately be seen to rise to the surface and burst. These bubbles are caused by the stearine penetrating into the gypsum, and driving out the air and moisture contained in it. As soon as the formation of gas has nearly subsided, the article is removed from the bath; it immediately appears dry. Graphite is sprinkled all over it while it is lukewarm; it is then allowed to get quite cold. Then the operator breathes on the surfaces that are to be metalized, and rubs them vigorously and continuously with a brush covered with graphite. This part of the process is very important, because the uniform appearance of the metallic deposit which the article is to receive depends upon it, and it demands much care and attention; a well-metalized object must be entirely black, and not show gray or white spots, as is so often the case. It is very difficult to apply the graphite to articles with deep hollows or projecting curves; in such cases, at any rate for the hollow portions, recourse must be had to the "wet" method of metalizing, which I will describe presently. It is commonly believed that it is necessary to use a very soft pencil or brush for applying the graphite. This is a great mistake, and is often the reason why beginners fail to produce good results. I use the so-called "watchmaker's brushes" or ordinary blacking brushes. These brushes may be vigorously applied, in order to make the graphite adhere well; no injury will be done to the figure. Only figures molded from wax require treatment with a soft brush. The process of saturating with stearine and metalising with graphite is adapted for articles made of gypsum, alabaster, etc. For wooden articles I prefer prolonged boiling in fatty oil or simple linseed oil to the treatment with stearine. The article must be wiped before applying the graphite. If the objects to be metalized cannot absorb anything, they are given a light coating of varnish, and the graphite applied when they are dry. This method may be used with advantage for articles of glass, stoneware, porcelain, horn, and ivory.—Der Metallarbeiter.

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